SCIENCE ABSTRACTS.

Section A.—PHYSICS.

OCTOBER 1923.

GENERAL PHYSICS.

1708. *Physical Constants.* (Tables Annuelles de Constantes et Données Numériques, 4. pp. 627–1016, 1922.)—Contains data relating to electricity, magnetism, metallurgy, etc. Collected for the years 1913–1916 inclusive, in continuation of previous volumes. W. R. C.

1709. *Report of the Physikalisch-Technischen Reichsanstalt for* 1922. (Zeits. Instrumentenk. 43. pp. 61–109, March, 1923.)

1710. *A Simple Regenerative Vacuum Device and some of its Applications.* **H. P. Waran.** (Phys. Soc., Proc. 35. pp. 199–202; Disc., 202–203, June 15, 1923.)—The paper deals with the difficulties arising from residual traces of air fouling the vacuum above the mercury column in syphon gauges and other devices. A remedy is suggested in the form of a small attachment taking the shape of bent capillary tubing ending in a bulb. This enables the air to be repeatedly pushed into the vacuum of this bulb, the mercury at the bottom of the capillary preventing the subsequent return of the air. With such an arrangement fitted to the top of a syphon gauge the height of the column of mercury becomes a true measure of the gas pressure, subject only to the definite correction for the vapour pressure of mercury and temperature. The device is regenerative in the sense that, irrespective of any progressive fouling of the vacuum, a fresh air-free vacuum is automatically created by it every time it is brought into action. As typical examples of the wide field of utility of the device, its application to mercury barometers and mercury-vapour lamps is also briefly discussed. AUTHOR.

1711. *The Theory of the Trevelyan Rocker.* **E. G. Richardson.** (Phil. Mag. 45. pp. 976–989, May, 1923.)—It has been assumed until recently that Sir John Leslie's theory of the action of the well-known Trevelyan rocker gave the correct explanation of the phenomenon. Heat being communicated to the lead block by the prismatic block of copper (with a groove in its under surface so that it would rock on the ridges), the rugosities of the surface of the lead were supposed to expand, to push up each ridge in turn, and then to contract as the heat diffused through the lead, the rocking being due to inequality of inertia of the portions of the rocker on opposite sides of the ridge. This theory, which may be called the "gravity" theory, has recently been questioned by Chuckerbutti [Abstract 2004 (1921)], who obtained some actual values for the amplitude, or height to which the ridge rises, and for the corresponding frequency of the vibration by a mirror carried on a thin rod, rolling on the back of the rocker. He concluded that the gravity theory was inadequate, and suggested that "the *elastic* vibrations of the rocker and handle-bar play an important part, and eventually displace any such simple rocking movement as may occur in the earlier stages." The work described in the present paper is an investigation of the relative merits of the "gravity" and "elastic" theories. If n is the frequency of vibration, R the amplitude at a ridge, $2a$ the distance between the ridges, and K the spin-radius of the rocker, $n^2R = a^2g/16K^2$. The gravity theory therefore requires the amplitude and frequency to be connected by the formula $n^2R =$ constant, whereas if the vibrations are elastic, the frequency should be independent of the amplitude when this is small, but dependent on the length of the rocker and handle. The results obtained are in favour of the gravity theory, n^2R being approximately constant, directly proportional to a^2, and inversely to K^2. The frequencies are found not to be of the order required for the "elastic" theory, nor do they vary with temperature in the manner required by this theory. T. B.

1712. *The Precision of a Valve-Maintained Tuning-Fork.* **D. Dye.** (Roy. Soc., Proc. 103. pp. 240–260, May 3, 1923.)—The great accuracy obtainable by this form of electric fork suggested this systematic experimental research into the effect on the frequency of the fork of variation of the following variables:—Temperature. Filament current and anode voltage. Grid and anode condenser capacities. Polarising magnetic field. Energy taken from the output winding. The addition of circuits in series in the anode circuit as alternative means of taking power. Extra mass added to various parts of the mounting of the fork. Absolute measurement of frequency.

The conclusions reached are: (1) Temperature change is the effect most liable to cause variation of frequency. Elinvar is suggested as a suitable steel for the fork. (2) Variation in voltage and filament sources causes no serious change in frequency. (3) Accidental variations in inductance, capacity, and resistance have negligible effect on frequency. (4) Magnetisation of the fork is deleterious because it increases damping, and also because it introduces stresses which react on frequency. (5) The energy is best taken from a circuit in series with the anode of the valve. (6) It is desirable to mount the fork very solidly and support on soft rubber pads. As a general conclusion the author finds that the valve-maintained fork is capable of operating with a steadiness of frequency which is greater than is necessary for most purposes requiring the highest accuracy. P. E. S.

1713. *Spectro-Radiometric Apparatus.* **W. W. Coblentz.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 439–454, June, 1923.)—A full bibliography and brief description of spectro-radiometer apparatus and methods. The regions of the ultra-violet, visible and infra-red, are separately dealt with, and special methods, such as focal isolation, are described. All the usual radiometric appliances are included and notes on galvanometers and vacuum maintenance given. The last section treats of light sources, standard and otherwise, and light filters. A. Wh.

1714. *Determination of Viscosities by the Oil-Drop Method.* **Y. Ishida.** (Phys. Rev. 21. pp. 550–563, May, 1923.)—Millikan determined the value of *e*, the elementary charge, from measurements of the rate of fall of charged droplets in air, assuming the coefficient of viscosity to be $1\cdot283 \times 10^{-7}$ [Abstract 1745 (1910)]. When *e* is known the method may be used to determine coefficients of viscosity. Thus these coefficients for argon, helium, hydrogen, methane, ethane, isobutane, nitrous oxide, and carbon dioxide (reduced to 23° C.) were found to be respectively 2210, 1981, 880, 1079, 927, 755, 1449, and 1471, each $\times 10^{-7}$. Carefully purified gases tested spectroscopically and by density measurements were used, and the values found are probably accurate within 0·3 per cent. Isobutane is the first gas whose viscosity has been measured near its condensation point.

As Millikan has shown from hydrodynamic and kinetic theory, the constant A in the correction term for Stokes' law $(1 + Al/a)$, is equal to the coefficient of slip ζ divided by the mean free path l, and also to $0\cdot7004(2 - f)/f$, where f is Maxwell's coefficient of diffuse reflection, hence from measurements of A both may be computed. The values of A obtained from experiments in the eight gases and air varied from 0·811 for H to 0·901 for He, while f varied from 0·926 to 0·874. For the elementary charge by the droplet method the measurements in air gave $(4\cdot770 \pm 0\cdot014) \times 10^{-10}$ e.s.u. J. J. S.

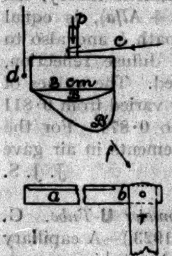
1715. *Gaseous Viscosity Measured by the Interferometer U-Tube.* **C. Barus.** (Nat. Acad. Sci., Proc. 9. pp. 71–72, March, 1923.)—A capillary tube of known length and radius is attached by rubber tubing to one limb of an interferometer U-tube. The air or other gas contained in that limb is put under a slight excess pressure above atmospheric by pushing the capillary into the limb, and is then allowed to transpire through the capillary. The viscosity of the transpiring gas is calculated from the determined constant rate of change with time of the logarithm of the displacement of the fringe system, and certain instrumental constants. J. S. G. T.

1716. *Determination by the Constant Deflection Method of the Value of the Coefficient of Slip for Rough and Smooth Surfaces in Air.* **L. J. Stacy.** (Phys. Rev. 21. pp. 239–249, March, 1923.)—The apparent coefficient of viscosity measured by this exceptionally precise method is not constant for lower pressures unless correction is made for slip at the surfaces. The relation $\eta_p'(1 + k\zeta_p) = \eta =$ constant, between η_p', the apparent viscosity coefficient, and ζ_p, the coefficient of slip, enables the latter to be determined from measurements of η_p' at pressures of 0·2 mm. or lower. The apparatus employed includes a vacuum-tight chamber inside which a cylinder of radius 5·431 cm. is suspended by a steel wire concentric with a cylinder of radius 6·063 cm. which can be rotated at a constant slow rate, so as to cause a steady deflection of the inner cylinder. The accuracy of this method is such that the values of $\zeta_{76} = \zeta_p p/76$ lie within ± 4 % of the mean. Difficulty is experienced in keeping the air pure on account of the gradual gas evolution (probably hydrogen) inside the apparatus. This effect is minimised by taking observations only shortly after evacuation.

For brass surfaces, ζ, reduced to 23° and 76 cm., is found to be $66\cdot15 \times 10^{-7}$, which is practically the theoretical minimum deduced by

Millikan for a completely diffusing surface ($65 \cdot 9 \times 10^{-7}$). For surfaces coated with shellac, the coefficient is found to be 97×10^{-7} for a fresh surface, which agrees with the value obtained by Lee from droplet measurements, but it decreases with time presumably on account of a roughening due to oxidation, falling in two months to within 3 % of the theoretical minimum. The coefficient of viscosity of air at 0·1 mm. is found to be the same as at atmospheric pressure when correction is made for the slip effect. The constancy of the values of ζ provides new evidence that the coefficient is independent of the pressure. A. B. C. L.

1717. *Sparkless Sparks.* **C. Barus.** (Science, **57.** pp. 420–421, April 6, 1923.)—The endeavour to remove all internal pressure from a soap bubble by charging it electrostatically usually only succeeds if the bubble is well anchored. A wind blower, as in the figure, with a small segment of bubble B projecting, is satisfactory. The charged bubble takes the form shown at B′; the expansion, on slowly increasing the potential, reaching a maximum, when it spasmodically jerks back to B, remaining intact. A pitch ball near the metallic holder shows a very slight but definite obliquity at each spasm. When at first the bubble is thick at the bottom (holding a drop, etc.) the first faint sparks imply an internal pressure reduction of less than 25 dynes/cm.². At the end when it is thinnest at the bottom the pressure reduction is usually 55 dynes/cm.², and here surface tension proper competes with electric pressure. The lines of force would seem to break off more easily from a liquid than from a solid surface, but owing to the varied curvature of the bubble it is difficult to ascertain the distribution of the contending forces. T. C. H.



1718. *Measurement of Speed of Rotation by a Stroboscopic Method.* **A. Guillet.** (Comptes Rendus, 176. pp. 1447–1449, May 22, 1923.)—A beam of light passes through a hole in a disc attached to a string, and illuminates a white disc with a radial black line, on the end of the rotating shaft. When the string vibrates the first disc moves to and fro in its own plane, and the second disc is only illuminated when the hole passes its position of rest. The tension of the string, and its vibration frequency, can be regulated by turning a graduated drum, until the black mark on the second disc appears to be at rest, owing to persistence of vision; and the graduations can be arranged so as to give the speed of rotation. H. N. A.

1719. *The Volume of the Mercury Meniscus.* **J. Palacios.** (Phys. Zeits. **24.** pp. 151–155, April 1, 1923.)—A series of measurements is conducted in order to determine the volume of the mercury meniscus of different heights and diameters, also to eliminate the influence on the results of variations of the surface tension of the mercury. The apparatus consists of a steel cylinder on the head of which a series of adapter rings of varying diameters can be attached. The cylinder is mounted on a travelling stage actuated by a micrometer screw. Above the cylinder a steel needle is mounted to point vertically downwards and, by means of a measuring screw, this can be adjusted to make contact with the mercury surface. After carefully levelling the apparatus, a measurement can, in this way, be made of the height of the meniscus at different points along a meridian of the surface and the area of curvature evaluated. The horizontal positions are plotted as abscissæ, x, and the vertical readings as ordinates, y, and an expression is derived for the area from the integral of the product xy as a function of the diameter and height of the meniscus. A calculation of the surface tension of the mercury from the measurements made show variations in this value to occur from 406 to 326. The values determined for the volume of the mercury meniscus agree closely with those calculated from the integral expression derived by Verschaffelt [see Abstract 235 (1922)]. J. N. P.

1720. *Atwood's Machine Used to Prove the Rotation of the Earth.* **J. G. Hagen.** (Zeits. Instrumentenk. 43. pp. 169–175, May, 1923.)—The author gives the equations of the coordinates of the falling weight from a previous publication, and describes experiments made with a fall of over 20 m., in which an endeavour was made to keep the acceleration constant by making the rising weight pull up strings of different thicknesses. The position of the string attached to the falling weight was observed by means of a theodolite near the bottom of the fall, and at two higher points; and it was found that, even when the attached string was only one-third of the thickness of that connecting the weights, there was over-correction, and the acceleration was smaller at the bottom than at the top. This was due to the fact that it proved impossible to make the correcting string run up smoothly in a straight line; waves were produced in the string, and the air resistance was increased. As a qualitative proof of the earth's rotation the experiment was quite successful; for demonstration purposes the falling weight may be provided with a point below, which pierces a card marked in circles about the position the point occupies when the weight swings at rest. The use of a damping vane on the pulley to keep the acceleration constant is suggested; or the two weights might be connected below by a hanging loop of cord if the pulley were made large enough. H. N. A.

1721. *Improvements in Gun Construction.* **T. Tanimura.** (Tokyo Imp. Univ. Faculty of Eng. 13. pp. 103–184, March, 1923. In English.)—Refers among other subjects to the stresses experienced in guns. W. R. C.

1722. *Effect of Temperature on some Properties of Steel.* **H. R. A. Mallock.** (Roy. Soc., Proc. 102. pp. 1–7, April 3, 1923.)—Gives results of experiments on the effect of temperature on the elastic coefficient of solids, especially as regards the variation of rigidities of iron and steel at high temperatures. During the author's first observations on the phenomena which accompanied recalescence in 1873–4, he had no means of measuring the temperature accurately, but he noticed the peculiar feature of re-extension and recalescence occurred at a higher temperature for iron than for steel and that, although it was evident from the diagrams that the contraction in terms of time followed the usual exponential law, both above and below the temperature of recalescence, it was also evident that the coefficient of the time in the exponent was different in the two cases. This difference indicated a change of specific heat, of temperature expansion coefficient, or of both of these, but without an independent measure of the temperature it was impossible to say how far each was responsible for the observed effect. The apparatus is described which was devised for the present series of tests, in which the period of torsional oscillation, the temperature, and the length of wire while cooling were continuously recorded. The chief results noted are: (*a*) A small and gradual change in the rigidity in the steel up to a dull red heat and its rapid decrease above the critical temperature; (*b*) that the rate of expansion shows no sudden change at that temperature, and that the expansion itself from 0° to 1000° C. can be fairly represented by a straight line. The expansion of a steel wire through this range of temperature might be taken as a tolerably good thermometer, and the constancy of the rate of expansion above and below the critical temperature proves that the difference in the exponential coefficient in the cooling curves, must be due to a change of the specific heat of steel while passing from the cool to the allotropic hot form. C. O. B.

1723. *Pressure and Conductivities of Metals.* **S. Lussana.** (N. Cimento, 25. pp. 115–130, 1923.)—The author's results of 1918 [Abstract 600 (1919)] and those of P. W. Bridgman [Abstract 1645 (1922)] are in some respects at variance. Critical discussion and comparison of the methods used. The author upholds his results of 1918. A. D.

1724. *Properties of Pitch Used in Working Optical Glass.* **F. W. Preston.** (Optical Soc., Trans. 24. 3. pp. 117–140; Disc., 140–142, 1922–1923.)—This has reference to effects observed with pitch when used for optical work, but certain physical information is also given, such as strain-time curves, surface traction, etc. W. R. C.

1725. *On Equations of Four Variables Capable of Representation by Simple and Double Alignment.* **d'Ocagne.** (Comptes Rendus, 176. pp. 1273–1278, May 7, 1923.)

1726. *A Device for Logarithmic and Semi-logarithmic Plotting and Finding Powers and Exponentials.* **R. A. Castleman, Jr.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 377–383, May, 1923.)—An apparatus designed for speedily plotting and determining the values of the constants in relations of the types $y = ax^n$ and $y = ae^{nx}$ by the customary methods of logarithmic plotting is briefly described. J. S. G. T.

1727. *Dimensional Considerations Based on the Hypothesis of Equal Distribution.* **J. Wallot.** (Zeits. f. Physik, 15. 1. pp. 61–63, 1923.)—The present paper is a rejoinder to Schiller's views on dimensions [see Abstract 239 (1922)]. Objection has already been taken to Schiller's method of regarding dimensionless magnitudes as constants without any further consideration [see Abstract 2195 (1922)], and the present author now argues that Schiller does not appear to be conscious of a difference between dimensionless and constant quantities. He then proceeds to criticise the majority of Schiller's propositions, which depend for the most part on the assumption that temperature may have the dimensions of energy, and draws the conclusion that on these lines the dimensional method is reduced to a mere play with ideas. H. H. Ho.

1728. *The Eötvös Torsion Balance.* **H. Shaw** and **E. Lancaster-Jones.** (Phys. Soc., Proc. 35. pp. 151–165; Disc., 165–166, April, 1923.)

—The Eötvös gravity balance in the Science Museum, S. Kensington, is described and the theory of it considered. An account is given of preliminary experiments on the torsion wire to ascertain the daily variation of the equilibrium position, due to strains set up in the wire during manufacture. The "baking" method recommended by Eötvös for ageing the wires proved quite successful. Tables are given showing the variation in the reading of the instrument, as the beam is rotated to different azimuths. The difference in the readings as azimuth varies indicate changes in the local gravitational field of the laboratory. The general expression which emerges from the theory is:

$$n_a - n = A \sin 2\alpha + B \cos 2\alpha + C \sin \alpha + D \cos \alpha$$

where n_a = scale reading corresponding to azimuth α
n = " " " zero torque.

A, B, C, D are constants at the station, involving derivatives of the gravitation potential with respect to the three coordinate axes, x, y, z. The instrument is very sensitive and temperature variations are avoided by having a triple case of brass round the torsion beam and whatever it carries. In the *discussion*, **H. G. Lyons** said the balance had proved commercially useful in the survey of oil fields in Egypt. P. E. S.

1729. *Sensitivity and Consistency of the Eötvös Torsion Balance under Laboratory Conditions.* **H. Shaw** and **E. Lancaster-Jones.** (Phys. Soc., Proc. 35. pp. 204–212; Disc., 212, June, 1923.)—A series of observations are made in a basement room of a reinforced concrete building at the Science Museum, South Kensington. At each point readings in six azimuths are taken, simplifying the calculations and allowing a simple and immediate check on the observations. A series of determinations are carried out at a point, the initial azimuth being advanced 10° after each set. Thus six sets are obtained and the direction of gravitational gradient deduced from each. The maximum error is 0° 45′, 1·6 %. The direction of the gravitational gradient is also found at one point on each day of a week, the maximum variation or error being 0° 50′. In three months, during which the instrument had been taken down and moved, the change is only 0° 40′. A series of observations were made at various points in the room and the directions and magnitudes of the gravitational gradient shown by arrows and curves of equal potential gradient. The effects of massive piers and neighbouring volumes of earth are also shown and agree with roughly calculated values. Third order derivatives of the gravitational potential are neglected in the calculations, which is not quite justified by the conditions, but the agreement is excellent. During experiments the temperature never varies more than 2° C. and the room is dark except for 30 seconds necessary to take an observation. In the field conditions will be far worse. A. Wh.

1730. *The Utilisation of the Eötvös Torsion Balance in the Field.* **D. Pekár.** (Zeits. Instrumentenk. 43. pp. 187–195, June, 1923.)—The author has already pointed out the advantages of the visual as compared with the photographic method for field measurements [Abstract 2372 (1922)]. He compares a series of observations taken with his perfected instrument by the visual method with one taken photographically by means of Bamberg's instrument; and finds that, while the first gives very consistent results, the deviations from the mean in the case of the second are very considerable. He points out the extreme minuteness of the quantities to be measured; if a gramme weight were drawn out into a wire, which could be wound twenty-five times round the equator, the force to which the torsion balance must respond is equal to the weight of one millimetre length of this wire, or 10^{-12} grs. The physicist should be in charge of the work, and should work up his preliminary data on the spot. It is not satisfactory to entrust the whole manipulation of the instrument to a subordinate, and send in the photographic records to a central office to be worked up; errors of adjustment, etc., should be corrected on the spot. H. N. A.

1731. *Determination of Gravity by Chronograph.* **D. Banerji.** (Indian Assoc. for Cultivation of Science, Proc. 8. 1. pp. 51–56, 1923.)—The falling-plate and tuning-fork method is here used photographically. Experiments are made in air and in a vacuum of 15–20 cm. of mercury. The results obtained for *g* in open air are consistent to 1 in 10,000; those obtained in vacuum being consistent to 1 in 30,000. P. E. S.

1732. *Errors in the Estimation to Tenths on the Centimetre Scales of Levelling Instruments.* **K. Lüdemann.** (Zeits. Instrumentenk. 43, pp. 33–50, Feb., and pp. 113–120, April, 1923.)—This paper deals with the problem of estimation to tenths in very exhaustive fashion both from the statistic and psychological standpoints. The main results are summarised as follows: Every decimal equation possesses a special form for each observer and each kind of observation. For different observers the equation is neither identical nor similar for each species of observation, while it admits of periodic secular fluctuations although capable also of remaining unchanged over long intervals. No particular tenth is uniformly estimated by all observers, although single tenths appear to find a definite preference or neglect by the majority. No special groups of outer or centrally situated tenths are uniformly estimated, although the average tenth of G. Lewitzky and the mean tenth of Bauch are apparently avoided by the majority of observers. The character of the interval measured and of the indicator used influence the form of the equation, which is to be regarded as the outcome of overlapping psycho-physical and physiological errors. A general theory of preference in estimations cannot be stated. The paper is packed with data and illustration. H. H. Ho.

1733. *Auxiliary Apparatus for use in Stereophotogrametry.* **O. v. Gruber.** (Zeits. Instrumentenk. 43. pp. 177–180, June, 1923.)—The author enumerates the requirements most important in the determination of a base-line, and describes apparatus designed to enable these requirements to be met as closely as possible. J. W. T. W.

1734. *Oscillations of Spheroidal Drops.* **R. N. Ghosh.** (Indian Assoc. for Cultivation of Science, Proc. 8. 1. pp. 57–71, 1923.)—Mercury is placed in a watch-glass, which is agitated isochronously by a mechanism vertically. Light is reflected to the bottom of the watch-glass and thence to a screen or photographic surface. Star-shaped figures are formed, the points in which are related to the frequency of agitation. From Rayleigh's energy method the relation between the natural frequency (N) of the oscillation and the number of star "points" (n) is obtained. But as Rayleigh's expression applies to infinitesimal amplitude, it is not so applicable to these experiments as that of Bohr's, which applies to finite motions. The observed frequency being 30, Rayleigh's formula gives results with error 35 %; Bohr's formula with error only 7 %.

In another part of this paper the spheroidal state of a liquid on a hot plate is dealt with experimentally and the theory is given. A relation is found in which the difference in temperature between liquid and plate varies as the fourth power of the gap between them. P. E. S.

1735. *The Corrected Form of Stokes's Law of Fall.* **R. A. Millikan.** (Nat. Acad. Sci., Proc. 9. pp. 67–70, March, 1923. Phys. Zeits. 24. pp. 273–275, July 1, 1923.)—A summary of papers not yet published. In them it is established that the final form of the law of fall for small particles is: $F = \frac{6\pi\eta a v}{1 + e/a(A + Be^{-ca/e})}$ where F is the force acting on a particle of radius a, moving with a resultant velocity v in a medium for which the viscosity is η and the mean free path e. By hydrodynamic and molecular reasoning it can be shown that $A = 0{\cdot}7004$ and $A + B = 1{\cdot}131$ for diffuse molecular reflection. Experiments on slip prove the existence of 7–12 % of specular reflection for oil droplets in various gases and a low value of A + B agrees perfectly with the deduction. For air-oil the complete law of fall is: $F = 6\pi\eta a v [1 + e/a(0{\cdot}864 + 0{\cdot}290e^{-1{\cdot}25a/e})]^{-1}$ and this may be taken as very nearly exact for all small particles. A. Wh.

1736. *Coefficients of Slip in Gases and the Law of Reflection of Molecules from the Surfaces of Solids and Liquids.* **R. A. Millikan.** (Phys. Rev. 21. pp. 217–238, March, 1923.)—First order correction term to Stokes's law of fall of droplets: (1) *Empirical.*—The experiments by which the value of the electronic charge is determined by the droplet method gives consistent results only when this law is modified by the factor $(1 + Al/a)$, (l/a = ratio of mean free path to radius of droplet). (2) *Hydrodynamic theory* gives as a first approximation $(1 + \xi/a)$, (ξ = coefficient of slip. (3) *Kinetic theory* gives $(1 + 0{\cdot}7004l/a)$ when all the molecules are diffusely reflected from the surface of the droplet, where l is defined by the relation $\eta = 0{\cdot}3502\rho cl$. If f is the fraction reflected diffusely, the factor is $[1 + 0{\cdot}7004(2f - 1)(l/a)]$. The numerical constant given by Cunningham's theory (0·79) is too high since experimental values of A nearly as low as 0·70 are obtained. In determining the coefficient of slip between solids and gases by the Stokes's law method, $\xi(= Al)$ may be computed directly from A. The rotating cylinder method can also give values of ξ accurate to 1 %. If θ_0 is the limiting deflection for high pressures, and θ the deflection for a low pressure, then ξ for that low pressure is $(\theta_0 - \theta)/K$, where K is a geometrical constant of the apparatus. Values obtained by this method agree closely with those obtained by the first method. In the capillary effusion method, where T_0 is the rate of flow of gas for unit pressure difference at high pressures, and T is the rate for a low pressure, then ξ for that low pressure is $R(T - T_0)/4T_0$, where R is the radius. Values of ξ/l vary with the surface, *e.g.* 0·70 for air-mercury, 0·87 for air-oil and air-glass, 1·07 for air-fresh shellac, and also with the gas, *e.g.* 0·81 for hydrogen-oil, 0·82 for CO_2-oil, 0·86 for air-oil, and 0·90 for helium-oil. The coefficient of diffuse reflection of gas molecules, determined from the relation $A = (2\eta/\rho\bar{c})(2/f - 1)$, gives values of f (for 23° C.) which vary with the surface from 0·79 for air-fresh shellac, and 0·89 for air-glass to 1·00 for air-mercury, and with the gas from 0·87 for helium-oil and 0·895 for air-oil to 0·92 for CO_2-oil and hydrogen-oil. A. B. C. L.

1737. *Apparatus for Composition of Vibrations.* **L. Counson.** (Assoc. Ing. El. Liége, Bull. 1. Ser. 7. pp. 121–131, April, 1923.)—Describes an apparatus for giving a record of the composition of two vibrations. The vibrations are obtained by ordinary pendulums. They are then communicated by connectors to a lever capable of simultaneous motions about two axes. One pendulum moves the lever about its vertical axis, the other moves it about its horizontal axis. The combined motions are traced on a plate by a pointer attached to the lever. The paper contains diagrams and a photographic reproduction of the apparatus complete. E. H. B.

1738. *Motion of a Sphere in a Fluid.* **P. Hirsch.** (Zeits. Math. u. Mechanik. 3. pp. 93–107, April, 1923.)—An experimental study, using balloons, bubbles, and small solid spheres, to discover how nearly the "equivalent mass" agrees with that calculated, *i.e.* actual + ½ (mass of fluid displaced). From the results for the initial stages of the motion, the value ½ was found, and it was shown that the effects of slight ellipticity, and viscosity, were within the limits of experimental error. For greater speeds, the path became sinuous on account of the vortices thrown off. W. G. B.

1739. *Whirling of an Overhung Eccentrically Loaded Shaft.* **S. Lees.** (Phil. Mag. 45. pp. 689–708, April, 1923.) *Note on Lees' Paper.* **W. McF. Orr.** (Phil. Mag. 45. pp. 708–714, April, 1923.)—(1) Corrects some errors in a former paper [Abstract 421B (1919)] due to a choice of coordinates insufficiently general. It is found that there is only one whirling speed, and that if the shaft can be safely speeded up through this, it is as safe as ever when this has been left behind. Internal elastic (viscous) friction will not prevent whirling, but external (air or bearing) resistance may. Yielding of the support may introduce two other whirling speeds, but the tendency to whirl at these may be masked by friction.

(2) Proves that the motion is exponentially unstable at high speeds, if the three moments of inertia of the pulley are all unequal. This may be the explanation of the observed evidence of instability of two-bladed aeroplane propellers. Points out that "stability" in the mathematical sense, and "safety" in the engineering sense are not always identical. A disturbance which is the sum of two or more terms may periodically attain an amplitude very great compared with its initial value. In some cases the absolute stability can be definitely proved, an integral of the differential equations being of such form (sum of squares, or essentially positive quadratic expressions) that it can be seen at once that the amplitude is limited. W. G. B.

1740. *Stationary Phase in Wave Motion Problems.* **G. Green.** (Phil. Mag. 45. pp. 1156–1167, June, 1923.)—In a former paper "On

Group Velocity and the Propagation of Waves in a Dispersive Medium" [Abstract 530 (1910)], the theory of group velocity is discussed from the standpoint of Kelvin's 1887 paper, "On the Waves Produced by a Single Impulse in Water of Any Depth, or in a Dispersive Medium." The group velocity theory is essentially identical with the "stationary phase" principle used in the above paper to evaluate $\xi = 1/2\pi \, . \int_0^\infty dk \, \cos [k\{x - Vt\}] : V = f(k)$, expressing the effect at any point x at time t of an impulse delivered at the origin at $t = 0$ in any dispersive medium. For each Fourier train corresponding to a value of k are the wave-length $\lambda = 2\pi/k$, the wave-speed $V = f(k)$, and the phase $\phi = [k(x - Vt)]$ at point x at time t. For ϕ near k_0, at x, t, $d\phi/dk = x - td(kV)/dk = 0$, or $x = \{f(k_0) + k_0 f'(k_0)\}t = Ut$, say. Thus the point of the medium at which the wave-length $2\pi/k_0$ predominates changes its position with the corresponding group-velocity U. According to the stationary phase principle, the wave-trains which contribute effectively to the resultant displacement of the medium ξ, at x, t, are included in a narrow range of k on either side of k_0, and the phase ϕ within this range may be represented accurately by a few terms of

$$\phi = k_0\{x - f(k_0)t\} + (k - k_0)d\phi/dk_0 + (k - k_0)^2/2! \, . \, d^2\phi/dk_0^2$$
$$+ (k - k_0)^3/3! \, . \, d^3\phi/dk_0^3 + \text{etc.} = A_0 + b_0/2! \, . \, \sigma^2 + C_0/3! \, . \, \sigma^3 + \text{etc.},$$

in which $d\phi/dk_0 = 0$, and $\sigma \equiv k - k_0$. The case treated by Kelvin and by later writers is that in which $d^2\phi/dk^2$ is large compared with any term coming after it. His evaluation is therefore restricted to ranges of x and t within which $d^3\phi/dk^3$ is extremely small relatively to $d^2\phi/dk^2$. The evaluation process consists virtually in replacing the curve representing the true phase of k from 0 to ∞ by one which coincides with the true phase curve only near k_0. The object of the present paper is to discuss fully the evaluation of ξ when the $d^3\phi/dk^3$ is included in the expression for the auxiliary phase curve. This happens when the phase curve itself has two points, k_1 and k_2, at which the phase is stationary. Then $d^3\phi/dk^3$ is not relatively small, but may become the predominant term, as, *e.g.* when the two roots of $d\phi/dk = 0$ are close together, or coincide, so that $d^2\phi/dk^2$ vanishes. The discussion therefore applies to all cases where there are maxima or minima, or both, of the group velocity, with respect to which Kelvin, at the end of his paper, observed that such cases will be particularly interesting, but that time did not permit of its being included in his paper. It is here very fully worked out, and it is shown that when k_1 and k_2 are far apart the result is obtainable by applying Kelvin's solution at each point of stationary phase separately. Solutions are developed by the author which are applicable both to the cases of k-points near together or far apart, making use of Bessel functions. The results obtained find application in determining the front of a group of waves advancing in shallow water; in connection with the minimum of the group velocity in waves governed by gravity and surface tension combined. The theory also allows of extension of the known solution of the ship waves problem whereby the motion near the line of cusps can be more accurately determined. It is, moreover, applicable to certain problems of energy propagation. The author promises later papers dealing with them separately.

G. W. DE T.

1741. *Steady Motion of a Cylinder through Infinite Viscous Fluid.* **A. Berry** and **L. M. Swain.** (Roy. Soc., Proc. 102. pp. 766–778, March 1, 1923.)

1742. *The Transformation of Voigt-Lorentz.* **P. Straneo.** (Accad. Lincei, Atti, 32. pp. 118–122, Feb. 4, 1923.)—An examination is given of the signification of the Voigt-Lorentz transformation and the use to which it may be put in the field of classical physics. J. J. S.

1743. *Polar and Axial Vectors in Physics.* **L. Prandtl.** (Zeits. f. Physik, 15. 2 and 3. pp. 159–163, 1923.)—Comments are made on a paper by F. Emde [Abstract 813 (1923)]. The distinction between polar and axial vectors is connected with the condition of mirror symmetry, and is important in physics. Akin to mirror reflection is inversion. Emde distinguishes two sorts of scalars, those which retain their sign with inversion which are called even, and those called odd, which change it. Contrary to the view of Emde, a distinct association of the physical magnitudes with the two classes is required. Accordingly masses and volumes must be taken as "even scalars." The electric vectors are polar, the magnetic axial; mechanical force is polar. In connection with an example given by Emde, it is shown that in calculation with inversion a special sign for the "odd scalar of value 1" brings all into order. J. J. S.

1744. *Fatigue Failure of Metals.* **C. F. Jenkin.** (Roy. Soc., Proc. 103. pp. 121–138, April 3, 1923.)—The author describes a theory which appears to offer a reasonable explanation of most of the principal phenomena observed when certain metals are tested. In this theory the following assumptions are made: (1) A metal test piece is made up of crystals with their cleavage planes oriented relatively to the axis of the test piece in many different directions. (2) The shearing stresses in the cleavage planes will differ according to the different orientations of the crystals, and slipping will begin in some crystals under lighter loads on the test piece than in others. (3) Slipping is resisted in the first instance by adhesion across the cleavage planes, and after it has begun, it is resisted by a force of the nature of solid friction which will generally be less than the adhesion. (4) Some of the crystals have initial stresses in them before any load is applied to the test piece, the forces exerted by the different crystals balancing each other. The load at which any crystal will slip will therefore depend on two things—its orientation and its initial stress. (5) Bauschinger's theorem that the fatigue range is the same as the elastic range is true. (6) When two parts of a crystal slip backwards and forwards on one another under an alternating load on the test piece, the slipping surface will wear and a crack will form in time and so initiate a fatigue failure, but this result is sometimes prevented by the gradual healing or sudden seizing of the slipping faces, and when healing takes place during a fatigue test, final failure will only occur if the wear and tear is faster than this recovery. This description of what is assumed to occur strictly only applies up to the point commonly called the yield point. Beyond this, the deformation of the crystals becomes considerable; after that point the behaviour of the crystals must be greatly complicated by mutual interference. The theory now proposed is therefore limited to stresses which do not exceed the yield point. If these assumptions be granted, all the principal phenomena of fatigue can be explained. This may conveniently be proved by showing that a model possessing the assumed properties behaves under test in all respects as metal test pieces do. A simple form of model is illustrated and described which is constructed so that it shall be elastic up to a point and then slip with solid friction, and that all the units shall not slip at once as the load on the model is increased. The results given by the model when tested in an ordinary static testing machine may be thus summarised: The model reproduces all the three typical load/strain graphs up to the yield point. It exhibits the difference between the limit of proportionality in tension and compression generally found in metal test pieces. It obeys Unwin's law on the raising of the limit of proportionality by stresses less than the yield stress. It reproduces typical hysteresis loops. When tested under alternating loads, the model complies with Bauschinger's theorem that the fatigue range is the elastic range. It exhibits Bauschinger's "natural" elastic limits after the same treatment that makes metals exhibit them. It gives the typical graphs for the complete series of fatigue ranges and confirms Bauschinger's and Bairstow's rejection of Gerber's parabola. It also exhibits permanent set after fatigue tests as metals do and reproduces Smith and Wedgwood's results for yield ranges. C. O. B.

1745. *Electrical Theory of Affinity and Valency.* **A. Campetti.** (N. Cimento, 25. pp. 5–36, Jan.–Feb., 1923.)—A critical summary is given of the work of Rutherford, Bohr, Born and Landé, Kossel, Lewis and Langmuir, on the structure of the atom, the constitution of matter, the nature of chemical affinity, and allied subjects. T. H. P.

1746. *The Electron-Absorbing Cross-Section of the Atom.* **G. Wentzel.** (Zeits. f. Physik, 15. 2 and 3. pp. 172–179, 1923.)—The great penetrability of the argon atom for slow electrons was shortly discussed by F. Hund, who came to the conclusion that it is actually the central regions of the atom through which the electrons pass and that the absorbing and scattering cross-section of an atom has the form of a ring. Rüchardt's calculations on the transfer of charges of H nuclei in canal rays (see preceding paper) lead to the same conclusion. The work of H. Kulenkampff on the continuous Röntgen spectrum is closely connected with the hypothesis of a ring-shaped absorbing cross-section, and the author has made calculations in order to determine the inner radius of the ring surface for swift electrons through comparison with the experimental results of Kulenkampff in their dependence on the electron velocity and on the charge of the nucleus. The formula obtained empirically is in agreement with the general theoretical expectations of Hund. Further, it is shown from calculations based on the chief results of the measurements of Ramsauer (on kathode rays) and Rüchardt (on canal rays) that it is also applicable to slow electrons although originally deduced from observations on swift electrons. J. J. S.

1747. *Dynamo-Kinetic Theory of the Electron and of the Atom.* **T. Tommasina.** (Comptes Rendus, 176. pp. 892–894, March 26, 1923.)—According to the theory here developed by the author, indivisible, indestructible units of energy, named energons, form the ultimate constituents of matter. The movement of the energon being indestructible, its dynamo-kinetic value is invariable. With energons, the internal activity of the electron, as an electrical element, is not merely inexplicable but mechanically inadmissible. The energon furnishes a mechanical explanation both of physical agents and of chemical atoms, since it transforms the material point, which is a mathematical abstraction, into a concrete, dynamo-kinetic element. **Erratum** (*ibid.* p. 1192, April 25, 1923). T. H. P.

1748. *The Calculation of the Electric Moment of the Molecule of a Substance.* **C. P. Smyth.** (Phil. Mag. 45. pp. 849–864, May, 1923.)—Debye has formulated equations for the electric moment μ of electric doublets, or dipoles, which form the molecules of gases and liquids; and J. J. Thomson has given a similar equation for gases. A more general equation has been developed by Gans, which includes not only ϵ the dielectric constant, but also D the density, N the number of molecules in a gramme-molecule, M the molecular weight, R the gas constant, etc. The author obtains an equation from that of Gans, which enables the electric moment to be calculated from the indices of refraction at two different wave-lengths, the density of the substance under the conditions under which these indices are measured, the dielectric constant at *one* temperature, the density at this temperature, the molecular diameter, and the above universal constants. For normal liquids this method gives results in good agreement with those obtained by the method of Isnardi and Gans. For strongly associated liquids, such as methyl alcohol, it leads to results which are low, but which give an idea of the magnitude of the moment, while the other method may lead to serious errors for such liquids. H. N. A.

1749. *The Connection between the Molecular Electric Moment and the Heat of Sublimation of the Halogen Hydrogen Compounds.* **M. Born** and **H. Kornfeld.** (Phys. Zeits. 24. pp. 121–124, March 15, 1923.)—There are many reasons for supposing that the above compounds, in the solid state, do not form ionic lattices like the salts, but molecular lattices [Abstract 1131 (1920)]. The strongest argument for this is the fact that the lattice energy U_{HX} calculated from the heat of sublimation S_{HX}, and the ionisation energy I_{HX} ($X =$ halogen; $U_{HX} = S_{HX} + I_{HX}$) is much greater than that obtained on the assumption of an ionic lattice, $U_{HX} = 545\sqrt{\rho/M}\ k$ cal. ($\rho =$ density, $M =$ molecular weight). It is usual in such cases to speak of homopolar combinations, which throws the problem into the pathless territory of the quantum theory, but the authors consider that such combinations should be regarded as lying between the homopolar and the heteropolar, the former class, in such molecular combinations as N_2, O_2 and the diamond, involving very large amounts of energy, and being explained by equality of phase of the electronic motions in the neighbouring atoms; while in HCl, etc., the energy of combination is small, and can hardly be attributed to the same cause. They suggest a structure in which one molecule is situated at each of the corners of a cube with edge $\delta/2$. The molecular doublets at each end of a cube diagonal point in the same direction along the diagonal. If the doublet at one corner of the cube points inward, towards the centre of the cube, those at the three neighbouring corners point outward, and conversely. The lattice is built up by shifting the cube through distances of δ in the three directions parallel to its edges. There are eight molecules in the unit cell; and the forces between the adjacent doublets hold the structure together. I_{HCl} is found to be 319 on this hypothesis, the observed value being 313, the corresponding numbers for I_{HBr} being 294 and 299. The agreement is better than could be expected for such an estimate. H. N. A.

1750. *Molecular Dimensions, Structure, and Internal Friction in the Halogens and their Hydrides.* **H. Schmidt.** (Zeits. f. Physik, 12. 1 and 2. pp. 24–27, 1922.) G. W. DE T.

1751. *Model of the Helium Atom.* **H. A. Kramers.** (Zeits. f. Physik, 13. 5. pp. 312–341, 1923.)—Calculation shows that, in the model representing the helium atom in its normal condition, in which the two electrons move about the nucleus in single quantum orbits inclined to one another, the energy content of the atom is 3·9 volts higher than the experimental value, the assumption being made that the ordinary mechanical laws apply to the motion and energy of the electrons. It is shown further that such motion is mechanically unstable. Thus, even in the simple model of the helium atom with two similar electrons, the ordinary mechanical laws do not hold, and it is hence uncertain if the energy function derived from these laws gives the physical energy measured by spectral terms and ionisation potentials. It is not considered that the above result casts doubt on the accuracy of the helium model, and some of the general grounds on which the latter is based are discussed. T. H. P.

1752. *Spectrum of Langmuir's Helium Model.* **H. Newboult.** (Phil. Mag. 45. pp. 1085–1087, May, 1923.)—The spectrum is calculated on the usual quantum assumptions for a model of the helium atom suggested by Langmuir [see Abstract 1005 (1921)], in which the two electrons vibrate about the nucleus in opposite directions. The lines calculated do not belong to any known spectrum. A. C. M.

1753. *X-Ray Determination of the Structure of Urea and Tin Tetra-Iodide.* **H. Mark** and **K. Weissenberg.** (Zeits. f. Physik, 16. 1. pp. 1–22, 1923.)—In the investigation of the structure of urea the method of crystal rotation was used. The rotation diagrams show a series of dots arranged along lines at right angles to the axis of rotation, and the nearly coincident crystal axis; in reality these "layer lines" are hyperbolic and all the interference dots on a layer line have the same index with respect to the principal axis if this is used, so that the $< hk0 >$ planes (the zone of the principal axis) lie on the equator, the $< hk1 >$ planes on the first, the $< hk2 >$ planes on the second, and so on. The identity periods I can be calculated from the distances e of the layer lines from the horizontal equatorial line. It is shown that by varying the direction of the axis of rotation, and as a consequence the direction of the X-rays through the crystal, which direction is always at right angles to the axis of rotation, data can be obtained for the determination of the dimensions of the space lattice, the space group, the symmetry of the molecules, and the position of the atoms. For urea there is only one space group, and one arrangement of the atoms, which is in agreement with the X-ray diagrams. The crystals are tetragonal scalenohedral (Vd^3); $a = 5\cdot 63$, $c = 4\cdot 70$; the

molecule is united in space and apart from H atoms is plane, with autosymmetry $C2v$; distance between two N atoms in the molecule is approximately 2 Å.; distance between centres of neighbouring molecules larger than 3·98 Å. and smaller than 4·62 Å.; two molecules in the lattice cell. SnI_4 is cubical; $a = 6 \cdot 04$ Å.; I atoms surround Sn in tetrahedral union. In a note R. O. Herzog claims great superiority for the method as compared with that of Debye and Scherrer. For details of the measurements and calculations the original paper should be consulted.
H. N. A.

1754. *The Structure of $NaBrO_3$ and $NaClO_3$.* **N. H. Kolkmeijer, J. M. Bijvoet, and A. Karssen.** (Zeits. f. Physik, 14. 5. pp. 291–295, 1923.)—This is a reply to a paper on the same subject by Vegard [Abstract 1039 (1923)]; and deals in detail with the discrepancies between his results and those of the authors [Abstract 1505 (1922)]. Some of these seem to be due to the neglect by Vegard of the action of β-rays. The results of Dickinson and Goodhue agree quite well with the authors'.
H. N. A.

1755. *The Lattice Structure of Lithium Haloids.* **H. Ott.** (Phys. Zeits. 24. pp. 209–212, May, 1923.)—LiCl, LiBr, and LiI were carefully freed from water, and examined by the Debye-Scherrer method. According to Groth all three crystallise in the cubical system. In all three cases the indices h_1, h_2, h_3 are unmixed and the atoms of the halogen element are arranged in a face-centred cubic lattice. In the case of LiCl it is possible to deduce, without photometric measurement of the lines, that the Li ions form the same lattice, shifted through half the cube diagonal; and the same structure probably holds in the case of LiBr and LiI. The following table gives the values of a, the length of the cell edge thus determined, and of a' the same length as calculated from the density as determined by Baxter:

LiCl.	LiBr.	LiI.
a $5 \cdot 14_3 \pm 0 \cdot 006$ Å.	$5 \cdot 48_0 \pm 0 \cdot 007$ Å.	$6 \cdot 00 \pm 0 \cdot 007$ Å.
a' $5 \cdot 13_4$ Å.	$5 \cdot 48_7$ Å.	$6 \cdot 014$ Å.

Using a long narrow slit to admit the X-rays to the camera it is shown that the correct value of the deflection can be obtained by measuring, not from the middle of one line to the middle of the corresponding one on the other side, but from inner edge to inner edge. With LiI it was found that the X-radiation from iodine fogged the plate. This was got over by surrounding the paraffined-paper cylinder containing the crystal powder with a tube of aluminium foil, cut away just enough to allow of the passage of the X-rays from the copper kathode, in and out.
H. N. A.

1756. *On the Quantelation of the Asymmetric Oscillator and the Elastic Spectrum.* **P. Tartakowsky.** (Zeits. f. Physik, 15. 2 and 3. pp. 153–158, 1923.)—The investigations of Born and Karman [see Abstract 626 (1913)], on elastic oscillations in the crystal lattice, have gone far to establish a theory of the solid state, although the present author inclines somewhat to the Debye theory, pointing out the simplicity of the mathematical treatment involved as being in its favour. His (Debye's) introduction of the method of asymmetric oscillations in the theory of solids has now been employed by the present author for the quantelation of the asymmetric oscillator. Its energy and oscillation frequency are given as functions of the quantum number, for which an upper limit is obtained from the periodicity condition of the motion. Every line of the elastic spectrum is broadened by this conception, *i.e.* possesses a fine structure. The centre of gravity of such a group is found to be displaced from the corresponding undisturbed (purely harmonic) line. For high temperatures the line displacement is proportional to the absolute temperature.

H. H. Ho.

1757. *Crystal Structures of the System Palladium-Hydrogen.* **L. W. McKeehan.** (Phys. Rev. 21. pp. 334–342, March, 1923.)—Palladium in the form of a fine wire, 1/4 mm. diam, or of a narrow strip 1/20 mm. thick, was more or less saturated with hydrogen and used to diffract X-rays of known wave-length as in the well-known powder method. Two crystal structures were shown to be present, both having a face-centred cubic arrangement of atoms. One, that of pure palladium, has a parameter $3 \cdot 900 \times 10^{-8}$ cm., whilst the other, that of hydrogen-saturated palladium, has a parameter ranging between $4 \cdot 000$ and $4 \cdot 039 \times 10^{-8}$ cm., depending on the degree of saturation. A value near the upper limit, say $4 \cdot 036 \times 10^{-8}$ cm., probably corresponds to a compound Pd_2H, with a density of 10·76 gm./cm.^{3}. The arrangement of the atoms may be as in Cu_2O, but there is no X-ray evidence for the position of the hydrogen atoms. All the evidence so far obtained indicates that in the absence of sufficient free atomic hydrogen, the saturated state is unstable or metastable and that the return to the hydrogen-free condition once initiated in any crystal proceeds rapidly to the end; also pure palladium is unstable in the presence of atomic hydrogen. A bibliography of 66 titles, mostly 1920–21, is appended.

A. B. W.

1758. *X-Ray Observations of Solid Benzol.* **B. Broomé.** (Phys. Zeits. 24. pp. 124–130, March 15, 1923.)—The paper contains the preliminary results obtained by means of the Debye-Scherrer method; the author proposes to continue the investigation, using the Laue method, in order to finally decide between alternative possible structures. Since benzol liquefies at 5° C. the experiments were carried out, either in the winter with open window at – 2° C. or in a special camera, which was surrounded with solid CO_2. Long exposures, up to 25 hours, were used; and as the benzol crystals evaporated quickly they were renewed five times during the exposure. In this way lines which cannot be observed with the ionisation camera were recorded, as many as twenty-five having been measured. The only goniometric measurement of benzol by Groth is stated by him to be a rough approximation, as the substance rapidly evaporates. Groth found rhombic symmetry, with the axial ratio $a : b : c = 0 \cdot 891 : 1 : 0 \cdot 799$. The optical properties indicate rhombic symmetry. A new determination of the specific gravity gave about 1·003 at 0° C. The specific gravity at – 80° is obtained by comparison of the spectrograms taken at – 2° and – 80°, and is estimated as 1·036, the accuracy being at most 2 %. Using Groth's axial ratio it is necessary to assign the smallest values of $\sin^2\theta/2$ to faces with comparatively high indices, and to assume at least 8 molecules in the elementary cell. Approximate agreement can be obtained with 4 molecules; and this is improved by making the axial ratio 0·849 : 1 : 0·832. There are other possibilities: an axial ratio of 0·757 : 1 : 0·702 requires 4 molecules per cell, the lattice constant $C = 6\cdot852 \times 10^{-8}$ cm., and the calculated specific gravity is 1·046, using all the good lines, and 1·035 using lines (2), (6), and (7), the indices of which are 200, 020, and 002. This seems to be the best interpretation of the data; but the agreement found in the position of the lines does not give sufficient proof of its correctness.

H. N. A.

1759. *The Crystalline Structure of Anthracene.* **W. H. Bragg.** (Phys. Soc., Proc. 35. pp. 167–168; Disc., 169, April, 1923.)—The author in an address recently published [Abstract 1246 (1922)] put forward evidence for regarding the benzene ring as an actual structure of ascertainable size and form, and deduced that the unit cells of naphthalene and anthracene should have two of their axes equal, the third axis being longer for anthracene than for naphthalene by the width of one ring. The experimental data then available supported this hypothesis only roughly; in the present paper it is shown that more reliable data, subsequently obtained from small but perfect anthracene crystals, agree with it very closely. It is pointed out that the X-ray data furnish a new and accurate method of determining the density of a crystal.

AUTHOR.

1760. *The Arrangement of the Atoms in Crystals of Cinabar.* **C. Mauguin.** (Comptes Rendus, 176. pp. 1483–1486, May 22, 1923.)—According to Descloizeaux, HgS has the symmetry ($\Lambda_3, 3L_2$), which allows of circular polarisation. There are seven triply periodic kinds of assemblage which give this symmetry, between which the study of X-ray reflexions enables a choice to be made. Sohncke's type (23–24) agrees with the observations, a particle being repeated along a ternary, helicoidal, vertical axis with pitch C equal $9\cdot51 \times 10^{-8}$ cm., and again through $A = 4\cdot15 \times 10^{-8}$ cm. along three horizontal directions a_1, a_2, a_3 120° apart. The product of the volume of the lattice cell and the density is equal to the mass of a single molecule of HgS. The atoms are on the binary axes (normal to the axis of the helix) belonging to the Sohncke structure, these binary axes are of two kinds; the first meet the axis at the levels $+c/3$, 0, $-c/3$, and the second at the intermediate levels $c/2$, $c/6$, $-c/6$; the Hg atoms are on one set, and the S on the other, so that along 0001 there is an alternated succession of Hg and S planes. The parameters u and v (ua and va being the distances of the Hg and S atoms from the axis) have not been determined; $u = v = 1/3$ would give a rhombohedric structure, with an Hg atom at the centre of the rhombohedron, and a S atom at each of the corners. This does not quite agree with the X-ray evidence, but must be near the truth; to obtain exact values the intensities of the reflexions would have to be measured, and the laws of diffusion of X-rays by Hg and S would have to be determined.

H. N. A.

1761. *Electronic Structure of the Spinels.* **M. L. Huggins.** (Phys. Rev. 21. pp. 509–516 May, 1923.)—The results of Röntgen-ray analysis

of crystals of the spinel group are combined with certain assumptions as to the distances between the atomic nuclei. The primary assumption is that the distance between the zinc and oxygen atoms in several zinc spinels is the same as that in zinc oxide. The distances peculiar to other elements are thus found and a large number of the group treated. The atomic radii of several metals are calculated, some for different valencies and tabulated. A suggestion is made that ferro-magnetism is due to the orientation of doublet and triplet groups of electrons in the atom, but no mechanism is put forward to connect the two properties.
A. Wh.

1762. *Crystal Structure of Calcite.* **C. Mauguin.** (Comptes Rendus, 176. pp. 1331–1334, May 7, 1923.)—The analysis of calcite shows that each simple cell in the crystal contains one atom of calcium, one of carbon, and three of oxygen, but two arrangements of these have been suggested. The more obvious necessitates that the distance between planes of various atoms shall be the same. The Braggs have suggested another form, and in this the oxygen atoms are so arranged that the distances between successive planes are double the other unit distances in the crystal. The author shows that this will be so in the case of all planes having, as indices, three unequal odd numbers. Reflection of X-rays from the planes 311, 511, and 313 confirms this deduction and Bragg's hypothetical arrangement.
A. Wh.

1763. *The Crystal Structure of Quartz.* **L. W. McKeehan.** (Phys. Rev. 21. pp. 503–508, May, 1923.)—Photographs by the powder method of X-ray crystal analysis have confirmed the space lattice proposed by others. A careful study of 30 possible arrangements has shown that the *arrangement of atoms* which best fits the observed intensities of the lines in the pattern differs somewhat from those previously proposed, maintaining more clearly the identity of the molecule SiO_2. These molecules are obtuse-angled isosceles triangles (angle at Si atom-centre, 115° 14′; distance between Si and O atom-centres, $1{\cdot}631 \times 18^{-8}$ cm.) lying in the basal planes of each of three interpenetrating hexagonal space-lattices, so that the crystal may be considered as built up of layers of molecules, much closer together than adjacent molecules in the same layer.
AUTHOR.

1764. *The Quantum Theory and Isotopes.* **J. W. Nicholson.** (Phil. Mag. 45. pp. 801–817, May, 1923.)—Various matters of importance in regard to the quantum theory of spectra and of atomic structure are grouped together and discussed, with mathematical development. In considering "pendulum-paths" in an atom, the simplest case of the pendulum-path of a single electron about a nucleus is investigated. It is shown that, assuming the electron to pass through the nucleus, no difficulty such as an infinite velocity is presented, the electron passing through the nucleus with the velocity of light. From an application of the theories put forward to the case of helium, the general conclusion formed tends to be adverse to the hypothesis of nuclei made up entirely of hydrogen.
A. B. C. L.

1765. *Electrostatic Lattice Potentials.* **O. Emersleben.** (Phys. Zeits. 24. pp. 73–80, Feb. 15, and pp. 97–104, March 1, 1923.)—

The paper is extracted by the author from his Göttingen Dissertation, 1922. The author refers to the work of E. Madelung [Abstract 327 (1919)], crediting him with having been the first to calculate the constitutional energy, or lattice potential, of a rock-salt crystal, to that of P. P. Ewald (Ann. d. Physik, 64. pp. 253–297, 1921) in developing rapidly converging series for lattice potential calculations, and to that of M. Born [Abstract 1076 (1922)] in showing that for a cubic arrangement of ions the calculation of the lattice potential could be reduced to a finite number of multiplications and additions, provided a certain function of three variables, the ground potential, is known at a certain number of points in the lattice. The paper is the outcome of a verbal suggestion from Born of the desirability of extending his method to other than the cubic lattice. In previous work it had been assumed, either that the potential was of the Coulomb type or that the interactions between other than adjacent ions were negligible. The author has found it possible to remove these restrictions by expressing the lattice potential in terms of the Epstein zeta-functions. These are generalisations from Riemann's zeta-functions developed by P. Epstein in the Mathematische Annalen, Vol. 56, 1903, and 63, 1906. Born's lattice potentials are obtained as a special case, derived from the more general form and applied in the second paper. The properties of the zeta-functions are expounded. G. W. DE T.

1766. *A Possible Periodic Alteration of Mass Owing to the Relative Motion of the Earth.* **K. Fehrle.** (Zeits. f. Physik, 15. 1. pp. 24–26, 1923.)—The author deduces from the results given in his previous paper [Abstract 1470 (1923)] the possibility, according to the theory of relativity, that the ratio between the atomic weights of different elements may be affected by the earth's movement through space, being different at intervals of six hours owing to rotation, and of three months owing to revolution round the sun. The effect depends on the position of each element on the author's curve, and is greatest for elements with small atomic weight. The probable amount of the effect is such that there seems to be a possibility of its detection by available experimental methods. H. N. A.

1767. *The Influence of Matter on Measurement.* **G. Krall.** (N. Cimento, 25. pp. 191–193, March–April, 1923.)—It is suggested that the period of any clock in a field of force has a period given by $t' = t(1 + \phi/c^2)^{-1}$ where ϕ is the negative potential and t the period in the absence of the field. If the potential energy of the mass m at a point whose negative potential is ϕ, is $m\phi$, the apparent mass will be given by $m' = m(1 + \phi/c^2)$. Then if two bodies act on each other, one at a point where $\phi = \phi$, and the other where $\phi = 0$, the change of momentum of the one will be given by $m'v' = m'\dfrac{dr'}{dt'} = m(1 + \phi/c^2)^2\dfrac{dr'}{dt}$, and of the other by $m\dfrac{dr}{dt}$. To satisfy the observation of momentum we must have $dr' = (1 + \phi/c^2)^{-2}$, $dr \fallingdotseq (1 + 2\phi/c^2)^{-1}dr$, which is in line with relativity theory. A. Wh.

1768. *Anomaly of Gravity on the Earth.* **F. Sacco.** (Accad. Lincei, Atti, 32. pp. 139–144, Feb. 18, 1923.)—The irregularity of gravity over the earth's surface—the defect in general over the continents and the excess over the oceans—has often been discussed. The author proposes to explain it from observation of the moon, and by considering what can be inferred from the condition of its primitive crust of consolidation. The portions of the moon's surface more or less elevated, called *terræ*, represent the scoriaceous surface first consolidated, which from terrestrial analogy may be considered as of an acid constitution with silica and alumina, probably partially pumiceous from great development of gas. This is analogous to the trachitic rocks of the earth and to the *sal* of Suess. The zones on the moon's surface which present the appearance of planes and are called, though improperly, seas, represent the regions last consolidated in the cooling of the crust. They are more or less depressed relatively to the *terræ*, and are more basic in constitution with silica and magnesia, resembling the basalt rocks on the earth (and the *sima* of Suess), and are more compact.

In the case of the earth above the metallic *Barisphere*, with a mean density of 6 to 7 and constituting perhaps $\frac{2}{3}$ of the globe, and the succeeding less metallic zones and magmas, comes the *lithosphere*, with a density varying between 2 and 3. This the author, from the analogy of the moon, considers to consist of two portions, (1) one of prevailing acid character rich in silica and alumina, which forms the foundation of the chief terrestrial continents with an average density of about 2·5, and (2) the regions which remained longer in the condition of magma and solidified later, of a prevailing basic character, magnesio-siliceous, compact, and resembling basalt with density above 3, from which was formed the substratum of the principal oceanic areas. J. J. S.

1769. *Basic Principles of Gravity Concentration.* **T. Simons.** (Am. Inst. Mining Eng., Trans. 68. pp. 431–450; Disc., 450–462, 1923.)—The subject is treated, in general, on the lines of Rittinger's mathematical analysis (Aufbereitungskunde, 1867), but with the employment only of simple mathematics and elementary mechanics. A general agreement with the results obtained by experimental methods is noted. A. B. C. L.

1770. *Inertial, Gravitational, and Field-Generating Mass.* **E. Reichenbächer.** (Zeits. f. Physik, 15. 4 and 5. pp. 276–279, 1923.)—The author considers that gravitational phenomena must occur transversely to a field of radiation in the presence of a field-generating mass. Brief allusion is made to the significance of this conclusion in connection with the experimentally-determined fact that hydrogen, of all the elements, possesses an atomic weight not in agreement with the whole-number rule, and in connection with certain cosmical phenomena. J. S. G. T.

1771. *The Gravitation Field.* **J. Le Roux.** (Comptes Rendus, 176. pp. 1544–1546, May 28, 1923.)—The illustrations of the difficulties of integrating Einstein's equations determining a given distribution of matter recently given by G. Darmois are interesting, and may serve for comparison of the results of Einstein's theory with those of observation, but the integration is not required for the general criticism thereof. The equations take the form $G_{\alpha\beta} = U_{\alpha\beta}, \ldots$ (1) where $G_{\alpha\beta}$ denote the coefficients of a covariant form deduced from the fundamental ds^2, while $U_{\alpha\beta}$ are functions of four coordinates defining the distribution of what Einstein's theory calls matter and energy. Given $U_{\alpha\beta}$, the equation (1) must be integrated to determine the coefficients g_{ik} of ds^2. But it is easier to take ds^2 as given and deduce $U_{\alpha\beta}$ by simple differentiation. And there appears no ground for assuming any relation between Einstein's matter and ordinary matter. Equations (1) are mere word definitions, empty space being defined as regions in which $U_{\alpha\beta}$ vanish. The author's criticisms are directed against the hypothesis on which Einstein's theory rests. They demonstrate the impossibility of accounting for the phenomena of gravitation in terms of a four-fold ds^2, the geodesics of which define the motions of matter. The essentials of gravitation—the solidarity and coordination of motions—disappear, since there exists no point-to-point correspondence between the points of two geodesics of one and the same form. And this defect is inherent in the theory. There is, therefore, no foundation for equations (1). Moreover, curvature of space or of the universe is not a geometrical concept, but is derived from an incomplete analysis of the concept of a line element and from an incorrect generalisation of Gauss's theory. In geometry, curvature is a differential invariant of the Euclidean group. If the Euclidean sense of the linear element is abandoned, there remains no ground for attributing to Gauss's invariant the sense of curvature. Again, in defining the components of the gravitation field, Einstein has to abandon rectilinear Cartesian coordinates in favour of general coordinates, subject only to the condition that to every point-event there corresponds a definite system of values of the coordinates. After constructing, for such a coordinate system, the general equations of motion of a point, he assumes that the necessary and sufficient condition that the motion should be rectilinear and uniform is that the coordinates used should be linear functions of the generalised curve *s*. That is to say, he assumes that the straight line is invariably characterised by linear relations between the coordinates, no matter what be the nature of those coordinates. For example, the spiral of Archimedes would be a straight line if expressed in polar coordinates. [See also Abstracts 819 and 820 (1923).] G. W. DE T.

1772. *Gravitation Field of Homogeneous Sphere.* **M. Nuyens.** (Comptes Rendus, 176. pp. 1376–1379, May 14, 1923.)—The author first refers to J. Chazy's determination of the ds^2 of a gravitation field due to a homogeneous sphere, for all points external to the sphere, the sphere being situated in a finite world (Comptes Rendus, 175, p. 1157, 1922). He then gives the solution for points within the sphere, and discusses various points connected with the problem of determining the ds^2 inside and outside such a sphere when the cosmological constant is given. He points out that de Donder's solution for points outside the sphere is obtained as a particular case of his solution when the cosmological constant is zero. G. W. DE T.

1773. *Secular Relativity Effects in Planetary Motions.* **J. Chazy.** (Comptes Rendus, 176. pp. 1542–1544, May 28, 1923.)—The author, replying to Trousset's contentions [Abstract 1321 (1923)], argues that they would involve the conclusion that every correction, of the order in question, of the Newtonian periodic time of a planet could be assigned to the major axis, so far, at any rate, as the two-body problem is concerned. But reasoning similarly, and attempting, from the equation $4\pi^2a^3/T^2 = f(M + m)$, to derive the limits of Mercury's mass, the resulting difference would exceed that of extreme values given by Backlund and Encke, respectively. In practice it is not the length of the major axis, but the times of revolution that are determined by observation, and the corrections of Newtonian times, even such as required by relativity theory, may be greater than the errors of observation. Consider *e.g.* the last and the next passages across the sun's disc of Mercury in May in 1891 and 1924, respectively. Assume that in the intervening 33 years Newton's law has held throughout the solar system with the known values of the osculating elements; and suppose this law replaced by that relativity theory or any one of the other four laws of force. In the latter case, the moment of the second conjunction in right ascension will be advanced by about 27 secs., or 145, 290, 51, or 41 secs. The substitution of one of these laws for that of Newton means, therefore, the assertion that the observed time of a planetary revolution consists of the Newtonian term ± a correcting term, the numerical value of which may be greater than the actual errors of observation. G. W. de T.

1774. *General Relativity Theory.* **H. Weyl.** (Phys. Zeits. **24.** pp. 230–232, June 1, 1923.)—The paper opens with the statement that, accepting the equivalence principle, it follows from the observed Doppler effect that light coming to us from a place of lower gravitation potential will become of lower frequency, involving displacement of spectral lines towards the red. The Doppler and Einstein effects are inseparable. The author has therefore formulated a simple principle, here reproduced from "Raum, Zeit, Materie" (5th Edition, 1823), enabling an observer in an arbitrary gravitation field to estimate the change in wave-length for any given motions of himself and a point source of light. Let s be the proper time of the light source Q situated on the world line L, and σ that of the observer situated on the world line Λ. From the points s, situated on L, (three dimensional) surfaces which are loci of constant phase of the light radiation travel towards the future within the opening sheet of the null cone K_s. K_s will cut the line Λ in a fixed point $\sigma = \sigma(s)$. The observer's impressions will be those due to the intersection by Λ of the advancing phase surfaces. If the emission from Q be purely periodic with vanishingly small period, the period will increase in the ratio $\rho = d\sigma/ds$ when measured in the observer's system. If the observer carry with him a source Q_0 of light of physical character identical with Q, the σ measured frequency of Q_0 will equal the s measured frequency of Q. Hence the ratio of $\lambda + \Delta\lambda$, the wave-length of the light received by the observer from Q, to λ, the wave-length of Q_0, will be given by $\Delta\lambda/\lambda = \rho - 1$.

Assuming the de Sitter cosmology, which the author considers preferable to Einstein's, and to what he has elsewhere denoted the elementary cosmology, the author considers two stars A and B of common origin and belonging to the same system, so that their world lines have the same action domain. This limitation is not made by de Sitter [Abstract 134 (1918)], nor by Eddington [Mathematical Theory of Relativity, pp. 161 *et seq.*], but it is a necessary condition for the homogeneity of space and time; without it the spectral shift towards the red could not be predicted with certainty. This deflection as seen in the spectrum of A by an observer on B will then be given by $\Delta\lambda/\lambda = \tan r/a$, where a is the constant world curvature and r the distance of A from B. It is then shown that $\rho - 1 = \tan r$, and that $dr/d\sigma = \sin r \cos r$. Hence it follows that the total spectral shift is greater than that corresponding to the radial velocity in the ratio 1 to $\cos^2 r$. The author points out the importance of this conclusion in connection with Eddington's table of Radial Velocities of Spiral Nebulæ [l.c., p. 162]. G. W. DE T.

1775. *Some Electromagnetic Consequences of Einstein's Relativity Theory.* **M. Morand.** (Comptes Rendus, 176. pp. 1211–1213, April 30, and pp. 1373–1376, May 14, 1923.)—The author finds that, by developing electromagnetic theory into the most general invariant form, in accordance with Einstein's relativity theory, it is possible to determine the electromagnetic field at every point in a Riemannian fourfold when the distribution of charges and currents is known. The differential equations obtained are much too complex for integration, but when simplified into the four corresponding to a Euclidean fourfold, and therefore to classical electromagnetic theory, some interesting consequences of Einstein's gravitation theory are obtained. An electrically charged particle subject to no forces other than the action of a gravitation field on its inertial mass, will, in consequence, move along a world geodesic. The particle when falling freely in a gravitational field will be surrounded only by its own electrostatic field. If the charged particle be held immobile at a point P by any external force, it will be surrounded by two fields: one electrostatic varying as r^{-2}, the other electromagnetic varying as r^{-1}, and composed of an electric and magnetic field, which together constitute the radiation field of the particle. The action of the electrical field on the particle will have a result which does not vanish, and having the direction of the gravitational forces. This is the weight of the particle. Thus is the existence of the gravitating mass of electricity explained. If the gravitation field at P were merely a geometrical in place of a permanent one, there would be no change in the character of the electromagnetic fields existing around the particle, but the resultant of the radiant reaction would be the force of inertia. Here we obtain a physical explanation of the existence and equality of the inertial and gravitating masses of which Einstein availed himself in his geometrisation of gravitational forces. Those results might have been predicted as an electromagnetic equivalence of geometrical and permanent gravitation fields. Indeed, the radiation terms calculated, the classical theory depends only on the acceleration of the particle, that is to say, on the components of the geometric gravitation field in which it is. Since a permanent gravitation field differs from a geometrical one with equal components only by derivatives of the g's of order higher than the first, it follows that all gravitation fields must give rise locally to the same radiation. G. W. DE T.

1776. *The Doppler Effect and Relativity Theories.* **P. A. Schultz.** (Zeits. f. Physik, 15. 2 and 3. pp. 121–125, 1923.)—Let K′ and K be the reference systems in which the light source and the observer, respectively, are at rest, θ' and θ the corresponding angles between the direction of the light ray and the velocity v of the light source, then, the frequencies ν' and ν, being related by the Lorentz transformation, are given by $\nu = \nu'(1 + \beta \cos \theta')(1 - \beta^2)^{-\frac{1}{2}}$, where $\beta = v/c$. Then for the aberration, $\cos \theta = (\cos \theta' + \beta)/(1 + \beta \cos \theta')$; so that

$$\nu = \nu'(1 - \beta^2)^{\frac{1}{2}}/(1 - \beta \cos \theta) \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

and for

$$\theta = 90^\circ, \ \nu = \nu'(1 - \beta^2)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

while in the classical theory, with the light ray perpendicular to v, $\nu = \nu'$. If then the Lorentz transformation holds, for $\theta = 90°$ the Doppler effect will be finite, the frequency will decrease, and the moving light ray will deflect towards the red. There must then be an angle θ_0 between 0° and 90°, for which the Doppler effect vanishes, *viz.* from (1) when $\cos\theta_0 = \{1 - (1-\beta^2)^{\frac{1}{2}}\}/\beta \ldots (3)$. From (1) and (2)

$$\lambda = \lambda'(1 - \beta\cos\theta)/(1-\beta^2)^{\frac{1}{2}},$$

where λ, λ' are the wave-lengths. Writing $\lambda' - \lambda = \Delta\lambda$,

$$\Delta\lambda/\lambda' = 1 - (1 - \beta\cos\theta)/(1-\beta^2)^{\frac{1}{2}} \ldots\ldots\ldots\ldots\ldots \quad (4)$$

which becomes $1 - 1/(1-\beta^2)^{\frac{1}{2}}$ for $\theta = 90°$. From (3) and (4), it follows that for $\theta = 180° - \theta_0$ $\Delta\lambda/\lambda' = 2(1 - 1/(1-\beta^2)^{\frac{1}{2}})$, double its amount for $\theta = 90°$. The author believes in the possibility of using these relations as criteria for discriminating between the classical (Newtonian) transformation and that of Lorentz. The former demands a displacement towards the violet for $90° > \theta > \theta_0$, the latter a displacement towards the red. The former also demands for all pairs of angles θ and $180° - \theta_0$ symmetrical positions for the displaced rays, relatively to the rest positions, and the latter asymmetrical positions. The author admits that the difficulty of obtaining accurate perpendicularity between the light track and the velocity of the source would make it impossible to make equation (2) a direct criterion, but suggests by using positive rays as the moving light source, it should be possible to determine the existence or non-existence of symmetry in the vicinity of the angle θ_0. For positive rays with velocity 2×10^8cm./sec., obtainable with a p.d. of about 30 kv., $\theta_0 = 89° 48' 33''\cdot 14$, and the Balmer line $H_\alpha = 6563$Å. represents the Doppler effect: $\Delta\lambda = -0\cdot 1467$Å. for $\theta = 90°$ and $\Delta\lambda = -0\cdot 2934$Å., for $\theta = 180° - \theta_0$.

In an appendix to the paper, communicated a week later, the author discusses and dissents from some remarks made by N. v. Raschevsky in a recent paper [Abstract 1529 (1923)], in which the latter rejects the possibility of utilising the Doppler effect as a criterion between the Ritzian theory, for which the Galilean transformation holds, and the Lorentz transformation. G. W. de T.

1777. *Space and Time in Relativity Theory.* **K. Bollert.** (Zeits. f. Physik, 15. 2 and 3. pp. 126–152, 1923.)—The author follows Kant in assuming that space and time are not derived from experience, but exist *a priori* in the mind, and also in the view that the inductive investigation of natural science is justified by the conformity to law of the relations between natural objects. Also in his conclusion that the minimum of congruence and uniformity that is necessarily conjoined with the concept of this conformity, therefore represents the *a priori* foundation of natural science. In order to make definite the concept of the physical continuum discussed at length in the paper, coordinates have to be introduced. Such a continuum can be constructed from a finite number of observations, provided that the distance between two adjacent points is represented by a definite quadratic differential form of the relative coordinates dx; in this case any infinitesimal rigid point system can move freely throughout the continuum. The only continuum throughout which *any* rigid point system can move freely is the Euclidean continuum. In the case of a four-fold world representation, not resolvable into space and time, it will always be possible to order the representation in accordance with the requisite functional conditions, since the sum total of the *a priori* foundations is equivalent to the two conditions: (1) That it is possible by observation to determine the space-time coincidences; (2) that from a finite series of such determinations all other world-points can be determined. Here is found the minimum of theoretical knowledge required to make the knowledge of nature a possibility. As its consequence it appears that for the continuum to be measurable it must contain infinitesimal congruent systems of world-points, or in other words, equidistant event-pairs must be capable of existing in every part of it. G. W. DE T.

1778. *Measurement of Einstein Plates in Canadian Eclipse Expedition.* **R. K. Young.** (Roy. Astron. Soc. Canada, J. 17. pp. 129–137, May, 1923.)—Two plates, E1 and E2, were taken in Australia in 1922 of the star field with the eclipsed sun present; two, C1 and C2, were taken at Tahiti, of the same region when the sun was absent, and one plate, I, of the same region was taken through the glass. The procedure of measurement was to clamp I with one of the four other plates, film to film, so that the pairs of images of the stars are reasonably close together, all over the plate; to measure the relative positions of the images; and to correct for atmospheric refraction (small since Wallal and Tahiti are nearly in the same latitude, and the plates were taken nearly at the same zenith distance), for aberration, and for all that makes for a change in scale (one set of plates being taken at night and the other in the daytime, so that temperature, barometer, focus, etc., are all different); the outstanding shift being attributed to Einstein's. Three solutions were obtained: (*a*) from E1, 1″·38, from E2, 2″·09; (*b*) omitting star BD 1·2628, from E1, 1″·30, from E2, 2″·17; (*c*) including BD 1·2628, but omitting the two most discordant stars, from E1, 1″·73, from E2, 2″·75. A. S. D. M.

1779. *A Mechanical Normal System is in general Quasi-Ergodic.* **E. Fermi.** (Phys. Zeits. 24. pp. 261–265, June 15, 1923.)—Let Γ be the phase space the points of which represent the coordinates of velocity and momentum. Then the path of a representative point starting from a point P_0 of Γ will lie wholly on the energy surface through P_0. The system would be called ergodic if this path included every point on this surface; but Rosenthal (Ann. d. Physik, 42. p. 179, 1913) and Plancherel (Ann. d. Physik, 42. p. 796, 1913) have shown this to be impossible. The author shows that in general the path passes infinitely near to every point on the energy surface, so that the system is quasi-ergodic. This he effects by extending a theorem due to H. Poincaré (Méthode Nouvelle de la Mécanique Céleste, vol. 1, chap. v) that a canonical normal system in general can have no analytical, single valued integral independent of the time other than the energy integral $F =$ constant. Geometrically, that is to say that in the phase space Γ, in addition to the energy surfaces $F =$ constant, there exists no family of surfaces possessing the property that a path of the representative point starting in any one of them remains confined to that one. This is generalised into: Other than $F =$ constant there is no surface having the property that paths starting in it remain in it, so that the proposition to be proved is: If an analytic single valued surface possess this property it must in general be one of the surfaces $F =$ constant provided η the number of degrees of freedom of the system be greater than two. Since the system is normal the velocities and momenta may be replaced by coordinates $y_1, y_2 \ldots y_n$ and $x_1, x_2 \ldots x_n$, for which the following conditions hold: F is independent of the time. Other than the coordinates x, y, F will contain a parameter μ, and for vanishingly small values of μ may be expanded in the form $F = F_0 + \mu F_1 + \mu^2 F_2 + \ldots$, where the F_i are functions of y and x and F_0 is independent of x. The configurations of the system, and therefore of F and F_i are purely periodic functions of x, of period 2π. A surface $S\mu$, $\phi(x, y, \mu) = 0$, is therefore assumed with the required property, ϕ being analytic, single valued and periodic in the x's. A difficulty occurs when P_0 lies on S_0. Although F_0 does not contain the x's, all the points of the path will have the same y values as P_0, while the x's are linear functions of the time. In n-dimensional space the path is therefore a straight line, but the periodic nature of the x's enables the points of this straight line to be enclosed in a cube of sides 2π, provided there exist no relation of the type $\Sigma m_i \partial F_0/\partial Y_i \equiv 0$. In other words, the undisturbed system must not be a degenerate one. If the number of degrees of freedom of the system be greater than 2; if it be not degenerate, and if three other types of relation are avoided, comprising in all the five conditions subject to which Poincaré's generalised theorem holds good, the author shows that his theorem—a mechanical normal system is in general quasi-ergodic—follows easily by means of a simple geometrical superposition. The foregoing set of conditions is sufficient, but not strictly necessary. Many cases in which one or more of them are infringed and the theorem still holds good may be found. G. W. DE T.

1780. *Tensors of Given Types in Riemann Space.* **P. Franklin.** (Phil. Mag. 45. pp. 998–1009, May, 1923.)—The author points out that one method of arriving at the natural laws of a group of phenomena, and one given prominence by relativity theory, consists in deciding upon the degree of mathematical complexity requisite, writing down the most general expressions of such type, and utilising known characteristics of the phenomena to determine or reduce in number the constants thereof. If the result explains the known phenomena in the field covered, it is accepted as a natural law; if not, more complex expressions are tried. With the addition of the condition that such expressions must be tensors, this is the relativity method. It therefore becomes important to determine what tensors of given types are possible, and it is with this object in view that the author states and demonstrates, or indicates the method of demonstrating six theorems. He believes theorems V and VI to be new, but it will be sufficient to state the latter, which includes V and also the known problems III and IV as special cases, indeed VI is obtained as a generalisation of the three preceding theorems. Theorem VI:—The most general tensor of given even order involving the g_{ij}'s and their first and second derivatives, these last linearly, is a linear combination of tensors which may be formed from the curvature tensor R^e_{fgh} and the fundamental quadratic tensor (g_{ij}) by multiplication and contraction. There are no tensors of odd order of the type required.

As an application of theorem II it is employed to derive the expressions for the stresses in a viscous fluid. Both it and theorem I refer to Euclidean space, referred to Cartesian coordinates. The author names them arithmetic tensors, defining an arithmetic tensor as having components which are constant, being independent of both the position of the point and the particular set of Cartesian coordinates used. Theorem IV is employed to arrive at Einstein's law of gravitation as the generalisation of Poisson's equation, as an example of its use. The author states that the point of view adopted in the paper is, in its precise form, the outcome of discussions in the Seminar of L. P. Eisenhart and O. Veblen at Princeton University. G. W. DE T.

1781. *The de Sitter Spherical World.* **H. Weyl.** (Phys. Zeits. 24. pp. 130–131, March 15, 1923.)—The author in this paper refutes the criticisms of K. Lanczos [Abstract 1052 (1923)] on his paper (Phys. Zeits. 20, pp. 31–34, 1919), and mentions that the whole cosmological question and the conflict of opinion between Einstein and de Sitter are exhaustively discussed in section 39 of the 5th edition (1923) of the author's work—"Raum, Zeit, Materie." G. W. DE T.

1782. *Acoustic Opacity of Banks of Cloud; Application to the Rapid Determination of the Thickness of a Cloud Layer.* **G. Reboul.** (Comptes Rendus, 176. pp. 1646–1648, June 4, 1923.)—The intensity of sound has been found to be much more feeble when a cloud bank is situated between the observer and the source of sound, than when no cloud is present. The thickness of a cloud bank may be determined to within about 500 m. by firing shells, arranged to explode at successive heights, and observing the intensity of the sound at points on the ground. When the explosion takes place above a cloud bank the noise is feebler, giving a discontinuity in the intensity of the sound observed. The height of this discontinuity gives the position of the upper surface of the cloud layer, and the thickness of the cloud bank can be found if the height of the lower surface is determined from a pilot balloon ascent. Observations were made by this method in 1918 and well-marked discontinuities were found at the upper surface of the cloud layers studied. A. W. L.

1783. *Variation of Nocturnal Temperature with a Clear Sky.* **J. Rivière.** (Comptes Rendus, 176. pp. 1643–1646, June 4, 1923.)—The author investigates the cooling of the lower layers in a calm atmosphere with a clear sky, assuming it to be caused by the heat loss by radiation towards the zenith and by conduction and radiation towards the ground. The equation deduced for the variation of temperature with time (in minutes) is:

$$\frac{1}{\theta^4}=\frac{1}{\theta_0^4}+\frac{10^4}{1\cdot161\mathrm{Ch}}\left[af_0\pi\sigma\,.\,\frac{\frac{4}{3\cdot5}k+\mathrm{K}}{af_0+\frac{4}{3\cdot5}k+\mathrm{K}}\,t+\frac{\rho}{\mu}\left(1-e^{-\mu t}\right)\right]$$

in which θ_0 is the initial temperature, θ the temperature at the ground at time t, and f_0 the vapour pressure which is assumed constant during the night. A modification of the formula is given for use if f is variable. The values of ρ/μ applicable to the observations of Marrakech and Meknès are $10^{-13}/(0\cdot165+0\cdot02f_0)$, and $10^{-12}/0\cdot04f_0$ respectively. A. W. L.

1784. *The Disturbance of the Uniform Temperature of the Stratosphere by the Vertical Displacement Associated with Horizontal Motion Governed by the "Geostrophic Law."* **F. J. W. Whipple.** (Phil. Mag. 45. pp. 778–782, April, 1923.)—The initial rate of change of temperature in the stratosphere is investigated, assuming: (1) That the motion is geostrophic, (2) that the temperature in the stratosphere at a given time is independent of height, (3) that effects due to radiation and eddy conductivity may be neglected. It is shown that temperature changes will be governed by the equation

$$\frac{b}{\gamma p}\,\frac{\cot\theta}{a}\,\frac{\partial V_N}{\partial h} = \frac{\partial}{\partial h}\,.\,\frac{\partial}{\partial t}\,.\log\theta - H\,\frac{\partial^2}{\partial h^2}\,\frac{\partial}{\partial t}\log\theta$$

where b is the gas constant, and H is the height of the homogeneous atmosphere. In the equation previously obtained by L. F. Richardson the term in H is omitted, although it may be of importance. Hence the correlation obtained between the two sides of Richardson's equation [Abs. 291 (1923)] is higher than would be expected. It is suggested that pilot balloon observations of the upward velocity up to great heights might show how some of the equations involved agree with observation.

A. W. L.

1785. *Decrease of Atmospheric Temperature Vertically Upwards and Similar Phenomena, as the Effect of Gravity.* **R. v. Dallwitz-Wegner.** (Zeits. f. Physik, 15. 4 and 5. pp. 280–286, 1923.)—The author attributes the vertical temperature gradient in the atmosphere to the action of gravity whereby the kinetic energy of a molecule of the air changes with height above the earth's surface in much the same manner as the kinetic energy of a projectile changes under similar conditions. On this assumption it is shown that the atmospheric temperature gradient should be about 0·01° per metre, which is about double that actually observed up to about 3 kilometres. The significance of the temperature gradient in its effect upon heat conduction from the earth, and the possible effect of the moon upon weather is briefly alluded to.

J. S. G. T.

1786. *The State of the Upper Layers of the Atmosphere.* **R. v. Dallwitz-Wegner.** (Zeits. f. Physik, 14. 5. pp. 296–300, 1923.)—Assuming that the atmosphere rotates on the average with the same angular velocity as the earth, and that at the boundary gravity just balances centrifugal force on the atoms, the height in latitude ϕ is $Ho = (42210/\cos^{2/3}\phi) - 6377$ km. A formula is worked out for the temperature at any height, and a table of temperatures is given. The earth's atmosphere has the form of an elongated ellipsoid of revolution, the diameter being 85,000 km. at the equator, and some 1,888,000 km. at the poles. At the boundary the temperature is zero absolute.

H. N. A.

1787. *An Automatic "Intensity" Rain-Gauge without Clockwork.* **J. W. Meares.** (Inst. Civ. Eng. Proc. Selected Engineering Papers, No. 2 [29 pp.] 1923.)—The author describes the experimental work which led up to the design of a fractionating rain-gauge consisting of a fine jet of variable trajectory, depending on the head of water in a vertical tube, discharging into one of a series of collecting vessels connected to a corresponding number of leaping weirs. Although designed mainly as a means of solving the problem of run-off in countries subject to heavy monsoon rainfall, the device can be used on light falls if a larger diameter gauge-funnel is used. By correlating the size of funnel and of jet, the water will head up in the vertical tube when the intensity of fall is high:

this gives a more horizontal trajectory and causes the nearer weirs to be overshot. Experimental results under artificial and natural rainfall are given. Further suggestions of the author and **J. H. Field** are made for recording fractionating gauges suitable for installation in places which can only be visited at long intervals. The effects of viscosity are examined in an appendix. AUTHOR.

1788. *Temperature of Air at Great Heights.* **F. A. Lindemann** and **G. M. B. Dobson.** (Roy. Soc., Proc. 103. pp. 339–341, May, 1923.)—In the region about 50–60 km. high, few meteors appear or disappear, and it is suggested that this is because, in this region, meteors pass out from a temperature of about 300° Abs. into one of about 200°, and their evaporation is temporarily checked. This effect is found to be greatest when the upper part of the atmosphere is warmest, *i.e.* in summer, indicating that the temperature difference in the upper regions between summer and winter exceeds, materially, that in the stratosphere. The authors suggest four other tests to prove that the temperature above 69 km. is higher than that between 10 km. and 50 km., and correct two arithmetical mistakes in their previous paper. [See Abstract 1069 (1923).] A. S. D. M.

1789. *Observations on the Spectrum of the Night Sky.* **(Lord) Rayleigh.** (Roy. Soc., Proc. 103. pp. 45–52, April 3, 1923.)—This paper is a continuation of the author's previous studies on the spectrum of the night sky. Specially designed spectrographs having a working aperture of *f*/0·9 are described. The northern and southern horizons have been photographed simultaneously on the same plate, and the aurora line recorded almost down to the horizontal direction in each. No marked difference of intensity between them was found. The negative nitrogen bands appear fairly often in photographs of the night sky spectrum exposed for several nights running in the North of England. They are always strong in the Northern Lights in Shetland.

The spectrum of the night sky shows two bright lines or bands in the violet and blue; the approximate positions being 4210 and 4435, as nearly as they could be determined on the very small scale spectra. The origin of these lines is not known. Besides there are the aurora line 5578, also of unknown origin; and the dark Fraunhofer lines H and K. A photograph taken about the same time by E. C. Slipher, of the Lowell Observatory, Arizona, also shows these lines. J. J. S.

1790. *Spectrum of the Night Sky.* **J. Dufay.** (Comptes Rendus, 176. pp. 1290–1292, May 7, 1923.)—Photographs of the spectrum of the night sky are taken with a quartz spectrograph of great light gathering power, the plates used being very sensitive to ultra-violet and violet, but insensitive to green and yellow. Thus while the auroral ray is not recorded a continuous weak spectrum is shown from 3200–4800 Å.U. This shows typical solar absorption lines, notably G, H, K, and L. The only difference between the spectrum and that of scattered sunlight is that it contains more ultra-violet. Two explanations are offered. Firstly, the light may be due to distant stars mostly of the solar type, or, secondly, it may be due to sunlight scattered outside the same ozone layer. Then the thickness of absorbing gas traversed would be less than in the case of sunlight scattered within the ozone layer. The first alternative is rejected as extremely improbable, and the results obtained are claimed as additional evidence of the presence of ozone in the upper atmosphere. A. Wh.

1791. *Study of the Green Auroral Line by the Interference Method.* **H. D. Babcock.** (Mt. Wilson Observat. Contrib. No. 259. Astrophys. J. 57. pp. 209–221, May, 1923.)—Observations by Lord Rayleigh have shown that the green auroral line may be observed in the background of the night sky when no auroral display is visible [Abstract 824 (1922)]. Observations with a Fabry-Perot interferometer have shown that it may be obtained on almost any night between the third and first quarters of the moon, and that the observations are not affected by moderate cloudiness. Various orders of interference were used for photographing, and it is concluded from the sharpness of the rings that the line width is not more than 0·035 Å. No evidence has been obtained to suggest any complexity in the structure of the line, but if satellites are present their intensity must be low. Considerable variations were observed in the intensity of the line, but the order of the surface brightness is 10^{-8} times that of the green radiation from a mercury arc in vacuum. In determining the wave-length two pairs of planes, three different separations, and three different pairs of metal films, both of gold and silver, were used. The mean wave-length given by the results is 5577·350 ± 0·005 I.A., the green mercury line and the strongest yellow neon line being taken as standards. A. W. L.

1792. *Murmur of the Forest and Roar of the Mountain.* **W. J. Humphreys.** (Washington Acad. Sci., J. 13. pp. 49–64, Feb. 19, 1923. Presidential Address.)—In many regions it is common to refer to the roaring of a mountain as an indicator of a general storm within six to twelve hours, and the sign is an exceedingly good one. The author deals in particular with the region of the Alleghenies, Gap Mills Valley, between Peters Mountains to the south-east and Gapp Mountain to the north-west. The prevailing trend of the ridge is N.E.–S.W., and the roaring is most persistent with strong S.E. winds. These are the winds of the forward or rainy side of a cyclone centred W. to N.W. of the region, hence the probability of bad weather following. Explanations of other phenomena are given, *e.g.* the facts that with light or no winds in the valley there are occasionally strong winds simultaneously up both sides of the top of the mountain ridge. This is due to a layer of strong wind, warmer than the still air filling the valley. The wind sweeps across the ridge, the tubes of flow are compressed at the top, creating a region of reduced pressure, so that air flows up the lee side forming an opposing wind. If the parent wind fills the valleys a similar effect occurs, but the opposing wind covers a bigger area of the lee side of the ridge. When the wind is strong it often beats heavily down on to a narrow belt, the "tempest belt," of the valley, while beyond in the valley and higher up the slopes of the ridge the wind is light. The parent wind, after sweeping over the ridge, and perhaps causing the opposed winds up the lee side, is forced down on to the valley, creating the tempest belt, and then rebounds so that on each side of the belt light winds may occur. If the parent wind is cold the effect is intensified owing to the greater density of the air. The intense roaring of the mountain is explained as the composite effect of the æolian tones of the twigs and branches of the mountain forest. The clouding of the mountain crest about the same time as the commencement of the roar, and the formation of an isolated roll of cumulus cloud along the leeward valley are also discussed. As already shown, the wind sweeping up and over the mountain is carried to an elevation above its level of equilibrium from which it drops down and then rises again, *i.e.* a few rapidly damped billows are set up parallel to the ridge just crossed. At the crest of the first wave the air is cooled by expansion, and condensation occurs, causing the isolated cloud parallel to the ridge. T. H.

1793. *The Earth's Rotational Deceleration and its Geological Effects.* **R. A. Daly.** (Am. J. Sci. 5. pp. 372–377, May, 1923.)—The possible causes and extent of the deceleration are surveyed. While tidal friction has been successfully invoked to explain the untraced element of the moon's acceleration, and this led naturally to a terrestrial reaction, other possibilities have been examined. Kelvin pointed out that since the eclipse observations of Nineveh, the deceleration is equivalent to that which would be caused by a transfer of water from equatorial to polar regions to a depth of 30 metres. Greater than this may have been the effect of crust movements and overthrusting in early Tertiary times. It is also pointed out that in Palæozoic and Mesozoic times there appear to have been large areas of shallow, nearly landlocked, sea in which tidal dissipation must greatly have exceeded its present proportions. The net probability seems to be that considerable deceleration has taken place in geological times. The nature of the reaction on the earth's crust is considered. The author tentatively suggests that an equatorial belt of land would be formed together with polar elevations, and that the East-west mountain systems would have been formed by the thrusts consequent on its subsidence. The author also suggests that certain N.W.–S.E. ridges on the bed of the Pacific may be wrinkles due to torsional stress developed by the greater tidal friction in the northern hemisphere. A. Wh.

1794. *The Stability of the Earth.* **E. F. S. Meissner.** (Roy. Astron. Soc., M.N. Geophys. Suppt. 1. No. 3. pp. 63–69, May, 1923.)—An analytical investigation of the radial stability of the earth, assuming certain distributions of density and rigidity. The density is given by Roche's law $\rho_0(r) = P(1 - \alpha r^2)$. The ratio of the velocities of the dilatational to the distortional seismic waves is almost exactly $\sqrt{3}$, and so Lamé's constants λ, μ are equal. It is further assumed that these are given by $\lambda = \mu = M(1 - \beta r^2)$. For distortional waves, then, $v = \sqrt{\frac{M}{P}}\sqrt{\frac{1-\beta r^2}{1-\alpha r^2}}$. There exists a minimum value of M, the rigidity at the centre, for which the earth is radially stable, and the analysis leads to the critical value, $M = 15 \cdot 2 \times 10^{11}$ c.g.s. units. Recently Schweydar has determined the actual value of M from observational data, and gives $M \fallingdotseq 33 \times 10^{11}$ c.g.s. units. The earth appears, then, to be far from a state of radial instability. A. Wh.

1795. *Co-Tidal Lines.* **E. Fichot.** (Comptes Rendus, 176, pp. 1292–1294, May 7, 1923.)—In a previous paper [Abstract 1519 (1922)] the author investigates the co-tidal lines with reference to a point of no tide in a canal of constant depth, open at each end, and traversed by equal waves in opposite directions, the rotation of the earth being taken into account. The present paper extends the method to a case similar, but in which the amplitudes of the waves are unequal. If the ratio of the amplitudes be ρ, it is shown that the resultant amplitude is reduced in the same ratio. The axis of the points of no tide is also shifted to a distance C log $\rho/4w$ from the median axis of the canal on the left hand with respect to the advancing wave of greater amplitude (northern hemisphere). In some cases the no-tidal axis lies without the canal, being then virtual only. This is the case in the English Channel, where the axis is well within the English coast. In the Irish Sea the axis is nearly tangential to the Irish coast. The lines of equal velocity and lines of flow are discussed, and it is shown that the co-tidal lines are more crowded in the neighbourhood of right sections through the points of no tide, and more widely spaced at intermediate points. The opposite holds for the lines of flow. A. Wh.

1796. *Determination of the Depth of the Chromosphere.* **P. Fox.** (Astrophys. J. 57. pp. 234–237, May, 1923.)—Light from opposite edges of the solar image formed by a telescope objective is reflected by four prisms on to the slit of a spectroscope. The distances between the prisms can be varied by a micrometer screw. The prisms are set well off the image, and then approached until the chromosphere lines appear. The difference between the reading and that when they just disappear again gives double the thickness of the chromosphere referred to the solar image. Preliminary experiments on the Yerkes 40″ refractor gave the chromosphere depth as 10″, determined from $H\alpha$ and 8″ from D_3. A. Wh.

1797. *Rotation and Height above Chromosphere of Filaments.* **L. d'Azambuja.** (Comptes Rendus, 176. pp. 950–953, April 3, 1923.)—The author has examined 16 determinations of the time of passage from the central meridian of the sun's disc to the central meridian again, of the filaments [dark absorption markings] between the years 1919 and 1922, and finds: that the mean speed at the equator ($14^\circ\cdot45$) is very nearly that of the spots ($14^\circ\cdot40$); that the mean speed does not differ sensibly from one filament to another, and so is independent of the form, intensity, and length of the filament; and that there is a clear indication of decrease in speed towards the poles, thus showing that the filaments obey the general laws governing other parts of the chromosphere and spots. But the mean speed of filaments on the visible hemisphere is variable from one filament to another, and is distinctly greater than the mean speed from one passage across the central meridian to another—the loss of speed being on the invisible hemisphere. The author attributes this difference to the position of filaments high up in the chromosphere giving a perspective effect, and he connects the filaments very closely with prominences, considering that they are the same phenomenon under a different aspect. A. S. D. M.

1798. *Spectrum of ζ Tauri.* **W. J. S. Lockyer.** (Roy. Astron. Soc., M.N. 83. pp. 326–331, March, 1923.)—The first part is historical. The second part deals with photographs taken in 1923, January and February, with the 9-inch prismatic camera of the Norman Lockyer Observatory. These show $H\beta$ as a thin sharp line with bright components on each

side, and the remainder of the hydrogen series as sharp lines without bright components; all the other lines are either very sharp or exceedingly fuzzy. Comparing photographs of 1923 with earlier ones, the author finds that, on 1896 February, Hβ was a dark broad line, like Hγ; on 1915 January, Hβ was thin, sharp, and dark with a strong bright component on the violet side; these seem to indicate that Hβ is variable. The author proceeds to show by comparison with the spectrum of α Cygni that the broad and diffuse lines are due to helium; the sharp and, on the whole, fainter lines to certain ionised metals; and that none are variable except Hβ. Using the helium lines, D. L. Edwards finds $-2\cdot 1$ and $0''\cdot 009$, respectively, for the absolute magnitude and the parallax of ζ Tauri.
A. S. D. M.

1799. *Wave-Lengths of Silicon Lines in Spectra of B-Type Stars.* **H. Barrell.** (Roy. Astron. Soc., M.N. 83. pp. 322–325, March, 1923.)—[See Abstracts 125 and 1073 (1923)]. The silicon lines investigated belong respectively to Lockyer's Groups II, III, and IV, and require increasing amounts of energy for their production. They are excited in the laboratory by condensed discharges, sent through vacuum tubes containing silicon tetrafluoride at pressures low enough to give the lines the requisite sharpness. Variations amounting to 0·05 Å., are traced to three causes, and the means of overcoming these are described. The new wave-lengths in Rowland's scale are as follows: 3856·165; 3862·737; 4128·207; 4131·038; 4552·782; 4567·995; 4574·908; 4089·016; 4116·257. The previously adopted wave-lengths in Rowland's scale are: 3856·161; 3862·727; 4128·204; 4131·040; 4552·762; 4567·967; 4574·918; 4089·12; 4116·33.
A. S. D. M.

1800. *Interferential Measures of Faint Diameters.* **M. Hamy.** (Comptes Rendus, 176. pp. 1849–1855, June 25, 1923.)—In his earlier paper [see Abstract 848 (1923)], the author gave in equation (1), the value of I, the luminous intensity in the direction θ, defining the terms θ, ϵ, l, a, τ, α, and m. He now develops the expressions $\frac{2}{\pi}\frac{\partial I}{\partial x}$ and $\frac{2}{\pi}\frac{\partial^2 I}{\partial x^2}$, where $x = 2m\tau$, and calls ξ, the smallest positive root in x of the system and μ, the smallest positive root in m which renders $x = \xi$, a double root of $\frac{\partial I}{\partial x}$. He finds $\xi = 5\cdot 577$ and thence $\mu_1 = m - 1\cdot 15\,\alpha^2 = 1\cdot 916 - 1\cdot 15\,\alpha^2$, and $2\tau = \xi/1\cdot 169 = 2\cdot 911$, if α is very small. Taking, then, these values as a starting point with $\alpha = 1/10$, for example, and substituting approximate values in the equations, the unknowns are found by interpolations such as satisfy the equations; and so on, adopting slightly higher values for α and approximate values for μ_1 and 2τ.
A. S. D. M.

1801. *The Determination of Photographic Magnitude.* **A. Bemporad.** (Accad. Lincei, Atti, 32. pp. 245–251, March 18, 1923.)—Various expressions have been given for the relation between photographic magnitude and the diameter of a star image on the photographic plate. Scheiner proposed $G = a - bD$ where G is the photographic magnitude and D the image diameter. This gives a straight line relation, whereas the expressions due to Christie, Kapteyn, and Charlier, which are respectively parabolic, hyperbolic, and logarithmic show convexity in one direction. The actual curve from comparison with photographs and estimated magnitudes, shows a distinct point of inflection, and an examination of the table of D for equal increments of G shows that the third order differences are constant. Hence an expression of the form $D = a + bg + cg^2 + dg^3$, where $g = G - 8$ is derived and a table of values calculated from the various formulæ given. The new formula is considered to give the best results.

A. Wh.

1802. *The Escape of Molecules from Gaseous Stars.* **E. A. Milne.** (Cambridge. Phil. Soc., Trans. 22. pp. 483–517, March, 1923.)—The pressure and density in a gravitating atmosphere whose temperature falls off as r^{-n} are investigated and the escape of molecules considered. At any level there is an effective "free solid angle" within which escape is possible. The actual number of molecules escaping from any level is given as the product of the free solid angle and a function of the density. This has, in general, a maximum, and the level at which it occurs is called the escape level. The escape of molecules from stars on Eddington's theory of internal equilibrium is treated, and it is shown that while the majority of stars are grouped about a magnitude for which the gravitational potential at the surface is a minimum yet the escape is usually negligible. The escape of electrons is also considered and estimates of the potential of various types of star obtained. While applications of the theory to stars take no account of radiation pressure and hence may be inaccurate, the theory may be precisely applied to the terrestrial atmosphere, and some escape levels and mean free paths for atmospheric constituents are given.

A. Wh.

1803. *Problem of Electron Capture in Stars.* **A. S. Eddington.** (Roy. Astron. Soc., M.N. 83. pp. 431–436, June, 1923.)—A simple and general derivation of the conditions depending for a free electron colliding with the nucleus [see Abstracts 1076 and 1077 (1923)]: (*a*) Without correction for change of mass with velocity, and (*b*) including the correction. For these the author obtains the formulæ $\sigma^2 = 2Nbdc^2/V^2$ and $\sigma^2 = 2Nb(d + \frac{1}{2}Nb)c^2/V^2$ respectively, where N is the atomic number of then ucleus, $b = \epsilon^2/mc^2 = 2 \cdot 81 . 10^{-13}$ cm., and d is the distance by which the electron is drawn in owing to the attraction of the nucleus from minimum distance σ. The electron in the neighbourhood of the nucleus is conditioned solely by the initial angular momentum σV, and does not depend on the initial energy $\frac{1}{2}mV^2$ which is unimportant. Capture occurs in the neighbourhood of the nucleus, proportional to V^{-2} or inversely to the temperature, and this leads to the law of absorption $mkT^{\frac{7}{2}}/\rho =$ const. The comparison of theory and measurement for the wave-lengths of the hydrogen spectrum points to the increase of mass of an electron with velocity when moving in the field of the nucleus; this gives a higher absorption-coefficient which is confirmed by calculation for Capella. The author considers an alternative mode of capture, *viz.* that the electron loses energy, by continuous radiation or by quantum emission, arising from its acceleration. He then answers Lindemann's criticisms [Abstract 1807 (1923)] concerning the amount of energy lost in an encounter and in the target for capture whose size, it was contended, should be the area of the ionised atom. He concludes that Lindemann's 10,000 captures per quantum is out of the question, and shows the two ways by which the number of captures can be deduced from the amount of absorption.

A. S. D. M.

1804. *Jeans's Theory of Origin of Spiral Nebulæ.* **H. Jeffreys.** (Roy. Astron. Soc., M.N. 83. pp. 449–453, June, 1923.)—The author accepts Jeans's argument from *Problems of Cosmogony and Stellar Dynamics* up to the equation $\Omega = V + \frac{1}{2}\omega^2(x^2 + y^2)$, proving that Ω is a constant over the boundary of the fluid. After that, he urges that the equator of the lenticular mass may have a sharp edge, not at all points, but at several only which will form conical points; and that if now tidal deformation is introduced, two conical points will be formed, one immediately below, and one directly opposite to the disturbing body, from which ejected matter will issue. But if Ω is not constant over the boundary, ejection will not be possible, unless the points of high tide are unaffected by rotation; if they are inverted, then ejection may take place at the two points 90° distant from them, or not at all. In a note, the author goes on to say that he has seen Jeans's answer to this criticism, and accepts his new proof [see Abstract following]. A. S. D. M.

1805. *Tidal Distortion of Rotating Nebulæ.* **J. H. Jeans.** (Roy. Astron. Soc., M.N., 83. pp. 453–458, June, 1923.)—A rigorous mathematical investigation of points raised by Jeffreys' criticism [see preceding abstract]. The author takes $V = V_M + V_T$, where V_M is the potential arising from the mass itself, and V_T is the external potential of the tidal field, assumed to be small. When $V_T = 0$, the solution is that for steady rotation; when V_T is not zero but a small quantity of the first order, the solution differs from that for $V_T = 0$ by small quantities of the first order, a case of special interest being that where V_T is proportional to a second degree harmonic. The working out of this case shows that a tidal field of the kind under consideration will result in all cross-sections of the rotating mass perpendicular to its axis of rotation assuming an elliptical shape. These major axes all lie in the same direction which is either that of the tidal pull or at right angles to it, but it is easily seen by a physical argument, that high tide must lie in the direction of maximum tidal pull, for the tidal field may be shown to produce no distortion of any kind. From the conditions of break-up at any point, this will first begin at the ends of either the major or the minor axis of the elliptic cross-section, and as every agency is more potent at the end of the major axis, there will be a continuous stream shot off from its extremities. If external tidal potential is absent, break-up begins simultaneously at all points of the cross-section in the equatorial plane, otherwise the equator becomes slightly elliptical and instead of a ring of matter thrown off, ejection is initially at two antipodal points only, these points being those at which the tidal pull is greatest. A. S. D. M.

1806. *Interior of a Star.* **A. S. Eddington.** (Nature, 111. pp. 5–12, May 12, 1923. Suppt. Paper read before the Roy. Inst., Feb., 1923.)—An argument of the factors participating in the conditions of the interior of a star from its centre outwards. *Example.*—Betelgeuse, a giant star, 10 million times the sun's bulk, only 50 times its material, a young red star, 3000° C. at surface, many millions of degrees C. at its centre, becoming hotter and smaller. At any point within it, there is a condition of balance, the weight of layers above pressing down the gas inside, the elasticity of the inside gas expanding it, and forcing out the layers above. Temperature is a mode of describing the speed of motion of ultimate particles, and inside a giant star each atom is pulled inward by gravitation of the whole mass, and "boosted" out again by collisions with atoms below. The energy of this atomic motion constitutes one part of the store of heat, and ethereal heat the other part. The condition of balance is between this ethereal energy (or radiation pressure) and material pressure, and a table is given showing the proportion for globes of gas from 10^{30} grms. to 10^{40} grms. The stars nearly all lie between such globes of 10^{33}–10^{35} grms. As stars grow smaller, surface gravity increases, and this introduces an important change in *ionisation* in the state of the gas, involving vast numbers of free electrons in the star, as well as atoms and ether waves. From this it is known that the average weight of the stellar material must be somewhere between 3 and 4. The author defines *opacity*, taking Capella as an example, its opacity being of the same order as that of terrestrial substances to X-rays. He shows how ether waves are not absorbed continuously by an atom, but in quanta, and describes how in his opinion [for objections, see following Abstract] the atom which is burst, and loses one of its satellite electrons, is repaired by capturing a free electron through actual collision of this with the nucleus of the atom. Finally, he discusses the source, in subatomic energy, of the energy maintaining the internal store of heat of a star, such as by building up complex elements from simpler ones, but shows how the earliest stars we know of do not consist of hydrogen; the process of element building from protons and electrons must have begun before the stellar stage is reached. He suggests that stars of very great mass (20 to 80 times the sun's) may be due to the accidental prevalence of hydrogen in the regions where they originated, matter there being in a more primitive state as regards the evolution of the elements. A. S. D. M.

1807. *Absorption of Radiation Inside a Star.* **F. A. Lindemann.** (Roy. Astron. Soc., M.N. 83. pp. 332–333, March, 1923.)—The author criticises Prof. Eddington's theory (that an electron, encountering an ionised atom, will be captured only if it hits the actual nucleus of the atom), on the ground of its being merely a numerical coincidence that the number of electrons liberated photoelectrically in unit time calculated from the absorption coefficient, is of the same order (one in 10,000 of the number of encounters with an atom per second) as that of the electrons actually hitting the nucleus. He urges that "for instance in iron, where there are some thirteen bound electrons, the chance of their all being on one side of the nucleus at any given moment is of the same order, but nobody would conclude that this condition decided whether an electron was captured or not." Of Prof. Eddington's assumption that only one encounter in 10,000 can result in recombination, he says it seems almost inconceivable that physically it should be true; that the electron having discharged its surplus energy in an inelastic impact should drop tamely into a vacant place in one of the satellite rings, and that an electron could pass and repass the K and L electrons without disturbing them. [See also Abstract 1803 (1923).] A. S. D. M.

1808. *Masses of Visual Binary Stars of Different Spectral Types.* **J. Jackson.** (Roy. Astron. Soc., M.N. 83. pp. 444–449, June, 1923.)—The parallax of visual binaries is only known accurately for a few near doubles, and these give, in the mean, a mass about twice that of the sun, confirmation of this value being also derived from Sirius, Castor, and four doubles which are both visual and spectroscopic binaries. The author uses proper motions as a method independent of parallax, for obtaining masses; he analyses 115 stars with orbit elements of mean type A2 to K2, and 326 stars with short arcs only, of mean type B6 to K1, the mean mass being deduced on the assumption that the solar velocity is 19·5 km. per sec. In both cases, the G-type stars give the same position of the solar apex, being about 20° different from that generally accepted. The stars with small arcs are open to sources of error which tend to make the resulting masses too large for early type stars and too small for late type. The author gives a diagram of his analysis, comparing his results with Seares' curve derived from absolute magnitudes, and the agreement is good except that smaller masses are indicated for late types than with Seares'. The results seem to show that binary masses fall from 12 times the sun's mass for late B stars to equality for K stars, but in the case of well-determined masses (as, for instance, two stars of type AO), these great values are not confirmed. It may be that the large mean masses for early type stars are the result of selection. A. S. D. M.

1809. *Certain Solutions of the Problem of Three Bodies.* **W. W. Heinrich.** (Bull. Astronomique, 2. 7. pp. 425–458, 1922.)—A mathematical discussion of certain new classes of "ideal orbits" in the case of a star, a planet, and an asteroid. A. Wh.

1810. *Intensities of Absorption Lines in Stellar Spectra.* **R. H. Fowler and E. A. Milne.** (Roy. Astron. Soc., M.N. 83. pp. 403–424, May, 1923.)—Saha's theory of high-temperature ionisation has thrown new light on the interpretation of stellar spectra, for if the relative intensities of arc lines and enhanced lines indicate the relative numbers of neutral atoms and ionised atoms in the gas which produces these lines, and if, further, the relative numbers depend upon temperature and pressure, we have a clue to the actual temperature and pressure conditions in stars.

Attempts have been made by this means to deduce a temperature scale for the sequence of stellar types, but Saha and Plaskett have done this by noting when a given absorption line is on the point of appearing or disappearing in the sequence. There are difficulties in this method which have already been discussed [see Abstract 1346 (1923)], and one main object of the present paper is to show that they are avoided by noting instead the place in the stellar sequence where a line attains its maximum intensity. The authors give formulæ for the theoretical maxima of different types of lines, and apply the results to observations of line-intensities in the sun and various stars whose temperatures are already approximately known: from these a pressure in the reversing layer of the order 10^{-4} is deduced, and this low value is borne out by recent work on other lines by various observers. A table is then given showing the calculated temperatures at this pressure for maxima of different series of various lines, side by side with the spectral types of stars in which the maximum intensities of these lines are observed; and a diagram shows the general sequence of star classes, series maxima, and temperatures, together with temperature scales from other sources for comparison. All the scales are in approximate agreement for types of stars cooler than class Ao, and the present investigation confirms them. For earlier types the investigation confirms the highest temperatures, and temperatures of 20,000° to 40,000° are suggested for O-type stars. M. A. E.

1811. *Spectroscopic Observations of both Components of Variable Double Star, X Ophiuchi.* **P. W. Merrill.** (Mt. Wilson Observat. Contrib. No. 261. Astrophys. J. 57. pp. 251–256, May, 1923.)—Double star: separation 0″·22 unchanged during 20 years; position angle decreased by 24° (Hussey and van Biesbroeck); spectroscopic parallax 0″·005 (Adams); possibly circular orbit of radius 0″·22, perpendicular to line of sight; distance between stars, 44 astronomical units, and combined mass, 0·95 the sun's; southern star of type Ko, apparent magnitude 8·9, and absolute visual magnitude 2·4; northern star, long period variable of period 337 days, of type M6*e* at maximum, when it is 0·3, absolute magnitude, and at minimum 6, absolute magnitude (spectrum unknown). Only case in which the absolute magnitude of a long period variable has been found by direct method, and at maximum it agrees with the mean value for giant M stars, and it is inferred that long period variables are in general giants. The radial velocities from the dark lines of both components agree well, but are considerably less than those from the bright lines. It is concluded that the dark lines give the true radial velocity, and that the bright lines are displaced to the violet by some unknown cause, probably within the star or its atmosphere. This is generalised for all variable M*e* stars.
A. S. D. M.

1812. *Luminosities and Parallaxes of 500 Stars, Types Fo to Mb.* **W. B. Rimmer.** (Roy. Astron. Soc., Mem. 62. 4. pp. 113–134, 1923.)—An investigation based on the fact that in stars of greater luminosity, certain high-temperature lines in their spectra are stronger with regard to the general character of the spectra than in stars of lesser luminosity, the reverse being the case for certain low-temperature lines. The negatives were photographed with the "McClean" 12-inch prismatic camera of the Norman Lockyer Observatory. The sources of error were dealt with in a paper by D. L. Edwards [see Abstract 875 (1923)]. The pairs of lines selected are 4078 Sr, 4072 Fe; 4227 Ca, 4216 Sr; 4216 Sr, 4250 Fe; 4290 Ti, 4272 Fe; 4444 Ti, 4455 Ca; 4455 Ca, 4462 Fe; but the pair λ4290 : λ4272, measured in the early types of F stars, gave variable results and were not used in absolute magnitude determinations. None of the later types of K dwarfs are included in the catalogue and no spectra of M type dwarfs are at present available. For absolute magnitudes in the range Fo to F7, pair λ4078 : λ4072 were given double weight, and similarly in the range F8 to K5 for the pair λ4216 : λ4250. Comparing the catalogue with Mt. Wilson results, a systematic difference is shown, which decreases from about ½ magnitude for A. 8, 9 to 1/10 magnitude for M*a,b*, the catalogue values being the fainter. The great majority of the stars examined are giants with parallaxes of the order (on the average) of 0″·025. The 500 stars selected for investigation include all the standard stars with spectra available, and the Mt. Wilson spectroscopic parallaxes and the trigonometrical parallaxes where known are given for comparison, as well as Boss's proper motions and the Henry Draper visual magnitude and spectrum. A. S. D. M.

1813. *Magnitude Equation of Osthoff's Estimates of Star Colours.* **E. Hertzsprung.** (K. Akad. Amsterdam, Proc. 26. 1 and 2. pp. 12–14, 1923. In English.)—An analysis of Osthoff's new catalogue of star colours up to 6^m shows that the estimated colour does not, as hitherto supposed, increase continuously with decreasing apparent brightness, but gives a maximum in the neighbourhood of 4^m or 5^m. This is due to peculiar colour perception by the human eye. If the spectrum of the sun is increased in intensity from the limit of visibility, the eye will perceive first the green and blue portion, but initially uncoloured; on the other hand, the red end of the spectrum will be seen as red as soon as it is perceived at all. This analysis clears up an unexplained magnitude equation in Leiden Ann. XIV, and at the same time forms an instructive example as to the danger of extrapolation, since 5^m is at once the limit of brightness of stars in Leiden Ann. XIV, and also where the magnitude equation of estimated colour changes character. A. S. D. M.

1814. *Stars in the Neighbourhood of* M_{36} (*N.G.C.* 1960). **C. H. Payne.** (Roy. Astron. Soc., M.N. 83. pp. 334–337, March, 1923.)

1815. *Distribution of Stars of Different Masses in Globular Clusters.* **E. Freundlich** and **V. Heiskanen.** (Zeits. f. Physik, 14. 3 and 4. pp. 226–239, 1923.)—Hitherto our knowledge of the distribution of mass in a system has been confined practically to double stars, but these are comparatively few in number, and do not afford evidence for all spectral types. Shapley has shown that in certain globular clusters investigated (*e.g.* M. 13), the sphere-like formation is shown only by the very bright stars, the giants, but for the more numerous fainter stars, there is a tendency to an ellipsoidal distribution, that is to say, there is a plane towards which the fainter stars seem to congregate. The authors show that the difference in brightness in globular clusters is an indication of difference in mass, and draw a comparison between the distribution of asteroids as regards Jupiter in planetary theory, and the distribution of small and great stars in these clusters. They infer the possibility of getting limits of mass for the two orders of stars. They analyse the distribution of M. 13, and show that the absolutely bright stars do not give a geometrically globular formation when divided according to spectral type, but the failure from the spherical form is not accidental; it seems to indicate a spiral structure. They also find for M. 3 and M. 13, on the theory of isothermal gas spheres, the relative frequency of the different types of stars with respect of the centre, and from this derive the mean masses for the types. A. S. D. M.

1816. *Observations of the Pleiades by the Heterochrome Photometer of the Paris Observatory.* **C. Nordmann** and **C. Le Morvan.** (Comptes Rendus, 176. pp. 1054–1057, April 16, 1923.)—R, B, and V are the luminous intensities of stars seen through the red, blue, and green screens, respectively, and the values of $y = \log \frac{B}{R} \Big/ \log \frac{B}{V}$ are tabulated for 22 stars of the Pleiades group. Other things being equal, if y is larger for a star A than for a star B, it signifies that for A, the relative intensities from the red to the violet, increases more rapidly than for the star B, between the red and the green, and less rapidly, on the contrary, between the green and the violet. In the table of 22 Pleiades stars, y is clearly a function of visual brightness, and increases as these decrease. Since the Pleiades form a group, all practically at the same distance from us, it follows that, on the average for the stars examined, y increases as the absolute magnitude diminishes. This is probably connected with an association of great intrinsic luminosity in stars with a small density in their absorbing atmosphere. A. S. D. M.

1817. *Movement of Line of Nodes in Spectroscopic Binaries and Variables.* **G. Shajn.** (Astrophys. J. 57. pp. 129–136, April, 1923.)—The movements of a satellite about a non-spherical central body must be perturbed, and the author finds that in the case of close pairs of stars, the secular motion of the line of nodes is always one of regression. The problem of the motion of the line of apsides in spectroscopic binaries and variables is analogous to the theory of the satellites of Jupiter, Saturn, or Neptune. For Jupiter V, the yearly motion of the line of nodes is about 960°. Generally if the inclination (γ) of the plane of the orbit to the equator is greater than zero, the effect may be considerable; the pole of the satellites' orbit will describe a circle of radius γ; the plane of the orbit will undergo a precessional motion and will not maintain the same inclination to the line of sight. Examples are taken from R. Canis Majoris and β Cephei. Guthnick has shown that the motion of the line of nodes may cause fluctuations in the duration of eclipse and range of brightness. From a large number of such observations, the author claims that some notion may be gained concerning the inclination (i), which, usually, cannot be found from spectral observations. A. S. D. M.

1818. *Dynamics of Globular Clusters.* **E. Freundlich.** (Phys. Zeits. 24. pp. 221–223, May 15, 1923.)—Shapley's determinations of the colour indices of the brighter stars in clusters give a new aspect to their structure [see Abstract 1815 (1923)] v. Zeipel and Plummer have shown from a consideration of the numbers, that the star densities in globular clusters obey the laws of a gas sphere in adiabatic, rather than in isothermic equilibrium, unless the cluster has progressed far in its evolution. But since the masses of the individual stars in clusters differ greatly (the brighter stars may range from 2 to 20 times the mass of the sun), the globular cluster must resemble, not a sphere containing one element only, but a mixture of differing atomic weights, and the author gives as the formula for their distribution $\rho = \sum_1^n \nu\rho v = \sum_1^n \rho^{(\nu)} e^{-2hm_\nu\Phi}$, where Φ is the value of the gravitational potential at the place considered. The author applies this investigation to M. 13 and M. 3, dividing the stars in them into two groups of colour index, *a–f*, and *g–m*, respectively, and illustrates this by two diagrams. For M. 13, indications of a spiral structure appear, so that the stars have not yet arrived at a stationary condition. In the A–F stars these signs of an unsymmetrical distribution are least and indicate a near approach to an "isothermic" condition. Such an investigation as that into the density of stellar distribution of M. 13 and M. 3, where one group seems nearer the isothermal condition than the other, affords a means of discriminating between the masses of the component stars. A. S. D. M.

LIGHT.

1819. *Refractive Index and Absorption Constants of the Diamond.* **F. Peter.** (Zeits. f. Physik, 15. 6. pp. 358–368, 1923.)—An account is given of measurements of the index of refraction of diamond crystals and the values found for various wave-lengths between $\lambda = 644$ and $\lambda = 226$ mμ are given. The absorption constants were measured from $\lambda = 226$ mμ to $\lambda = 546$ mμ. J. J. S.

1820. *Light Weakening by Reflection and its Application in Spectral Photometry.* **K. Schaum and S. Selig.** (Zeits. wiss. Phot. 22. pp. 148–162, June, 1923.)—This is the first of a series of contributions to spectral photometry. Various simplifications have made the Hartley-Baly method for investigating absorption in the ultra-violet region more readily usable for chemists. The principle of this method is the following: Of two originally identical bundles of rays which pass into the spectrograph, one (1) does so after traversing the absorbing substance, the other (2) without spectral change by this, but under otherwise similar influences. Both produce a "twin spectrum" consisting of the absorption spectrum, (1) and the comparison spectrum (2). If in the comparison bundle (2) by a photometric arrangement all the wave-lengths have been equally weakened or if the time of exposure for taking the comparison spectrum (2) has been made shorter than that for taking the absorption spectrum (1), then in general in the twin spectrum one or more places will be found at which regions lying over each other and thus corresponding to the same wave-lengths exhibit equal blackening. Thus the weakening of light produced by the absorbing substance can be calculated. In this paper the weakening of light produced by reflection and its application in spectral photometry is dealt with. By means of the Martens blackening measurer the enfeeblement of light for plane parallel plates, with polished or unpolished surfaces, as well as for layers from opaque media was investigated. J. J. S.

1821. *Determination of Focal Distances and principal Points.* **H. Erfle.** (Zeits. Instrumentenk. 43. pp. 54–58, Feb., 1923.)—Notwithstanding the numerous methods for the determination of the focal distance, the author offers a new process, applicable to any system, of lenses or of lenses and mirrors, based on a double use of the Newtonian equation $rr' = f^2$. Several examples of the method are included. By the practical extension of the process the accuracy of the autocollimation method can be increased. H. H. Ho.

1822. *Electromagnetic Theory of the Scattering of Light in Fluids.* **K. R. Ramanathan.** (Indian Assoc. for Cultivation of Science, Proc. 8. 1. pp. 1–22, 1923.)—An electromagnetic theory of the scattering of light in fluids is worked out without assuming a molecular structure on the basis of Lorentz's treatment of the scattering of light in gases, and the Einstein-Smoluchowski formula for scattering is deduced. The same result is shown to follow if the fluid medium be supposed to be

made up of isotropic molecules. The treatment is extended to the case of anisotropic molecules when it is shown that if the orientations of the molecules are entirely at random the transversally scattered light is imperfectly polarised. The observed values of the imperfection of polarisation in liquids are compared with the calculated values, and the latter are found to be uniformly much too high. This seems to show that the hypothesis of random orientations of molecules in liquids, which was assumed in the development of the theory, does not hold good.
J. J. S.

1823. *Scattering of Light by Liquid Droplets.* **B. Ray.** (Indian Assoc. for Cultivation of Science, Proc. 8. 1. pp. 23–46, 1923.)—The paper deals with various optical effects shown by clouds of small liquid droplets: (1) coronas, (2) glories or brocken-bows, (3) white rainbows, and (4) polarisation of scattered light. Simpson's theory that iridescent clouds seen at large angles from the sun are really fragments of unusually large coronas formed by exceedingly small droplets is verified experimentally. The glories seen when a bank of cloud is viewed by reflected light are shown to be an independent phenomenon due to primary scattering of the sun's rays by the droplets of water and are not coronas due to secondarily scattered light. Experimental observations are described and the theory is worked out mathematically. The light scattered back nearly in the direction of the source within the region $\theta = 0°$ to $\theta = 45°$ shows remarkable alternations of its state of polarisation in different directions. Calculation on the basis of the electromagnetic theory indicates that the elementary theory of coronas is considerably at fault in the case of very small drops, and also that Airy's theory of supernumerary rainbows ceases to be applicable in the case of very small drops. J. J. S.

1824. *Scattering of Light by Dust-Free Liquids.* **W. H. Martin** and **S. Lehrman.** (J. Phys. Chem. 27. pp. 558–564, June, 1923.)—An account is given of experiments on the effect of change of temperature on the light scattered by the three liquids, benzene, heptane, and naphthalene. It was found that the intensity of the scattering increases with temperature and passes through a very great value at the critical temperature, falling off again rapidly above the critical temperature. The scattered light becomes more nearly plane-polarised towards the critical temperature and in the immediate neighbourhood of that point is almost but not quite completely plane-polarised. J. J. S.

1825. *Molecular Scattering of Light in Benzene.* **K. R. Ramanathan.** (Phys. Rev. 21. pp. 564–572, May, 1923.)—The intensity of the light scattered at right angles was determined relative to that scattered by liquid ether at 35° C. [Abstract 312 (1923)] by photometric comparison with the aid of reflecting prisms and a sectored disc. The relative intensity increased with the temperature at an accelerated rate; for the liquid from 3·2 at 35° to 102 at 283°, and for the saturated vapour from 0·95 at 182° to 11·9 at 267°. The scattered light is not completely polarised. The imperfection of polarisation was measured by use of a double-image prism and a nicol. The ratio of the weaker to the stronger component, r, was found to decrease from 7·2 to 0·9 per cent. for the vapour and from 43 to 2·8 per cent. for the liquid as the temperature rose from 35° to 280°. Rayleigh, Born, and others attribute this imperfection to the anisotropy of the molecules. The theory as extended by Raman to the general case of fluids leads to the relation $Sr/\rho(1+r) = \text{const.}$, where S is the intensity and ρ the density. This agrees satisfactorily with the observations for both vapour and liquid. Since for the vapour the intensity S increases with the temperature much more rapidly than the density the Rayleigh law is not valid. The Einstein-Smoluchowski formula agrees much better, but when calculated values of the refractive index and compressibility are inserted it gives for the scattering in the vapour values which are 20 per cent. or more too high. J. J. S.

1826. *Absorption of the Ultra-Violet Rays by Phosphorus and some of its Compounds.* **J. E. Purvis.** (Cambridge Phil. Soc., Proc. 21. pp. 566-567, June 15, 1923.)—The absorption capacity of the vapours of phosphorus, PH_3, and PCl_3 has been studied. The vapours were enclosed in two brass tubes 100 mm. and 200 mm. in length. A small portion of *phosphorus* was placed in the 100 mm. tube which was filled with nitrogen and heated in a sand bed. There were no absorption bands. As the temperature was raised at about 150° C. general absorption began at about $\lambda 2500$, at 190° at about $\lambda 2820$, at 220° at about $\lambda 2960$. In another series of experiments with the 100-mm. tube, the rays were transmitted at 120° to $\lambda 2100$, at 160° to $\lambda 2500$, and at 200° to about $\lambda 2740$. There were no absorption bands. Using the 200-mm. tube heated in a water bath the phosphorus melted at 50°. At 70° the rays were transmitted to about $\lambda 2130$; at 100° to about $\lambda 2420$.

In the 100-mm. tube filled with *phosphorus hydride* at temperatures between 30° and 100° the rays were transmitted to about $\lambda 2230$; in the 200-mm. tube to about $\lambda 2240$. No absorption bands were seen. With *phosphorus trichloride* in the 200-mm. tube no bands were seen between 16° and 100°; at 16° the rays were transmitted to $\lambda 2480$ and at 100° to $\lambda 2590$. Thus neither phosphorus nor its compounds examined exhibit absorption bands in the ultra-violet regions. The oscillations or vibrations of electrons are supposed to be the origin of specific absorption in these regions, but in the molecule of phosphorus the four atoms and their electrons have not sufficient freedom to produce any specific effect.

J. J. S.

1827. *Studies of Iridescent Colour, and the Structure Producing it.* **(Lord) Rayleigh.** I. *The Colours of Potassium Chlorate Crystals.* (Roy. Soc., Proc. 102. pp. 668–678, March 1, 1923.)—The structure of the iridescent potassium chlorate crystals investigated by Stokes and the late Lord Rayleigh is examined microscopically. The periodic twinned structure inferred by the latter is clearly shown in the photographs taken under the microscope with polarised light. Some crystals have exceedingly complex structure, showing many groups of evenly spaced twin planes and a very complex reflection spectrum. It is shown that this results from high interference from terminal layers situated a considerable distance apart. Chlorate crystals, giving a silvery reflection, were obtained by Madan, who heated the ordinary colourless crystals to about 250° C. The complex twinned structure induced by this treatment is investigated, and photographs of the structure of the crystal and of the reflection spectrum are reproduced. There are corresponding irregularities in each resulting from want of flatness in the twin planes.

II. *Mother-of-Pearl.* (Roy. Soc., Proc. 102. pp. 674–677, March, 1923.)

The results obtained with this substance are in general agreement with those of Brewster and Pfund [see Abstract 629 (1917)]. Microphotographs are reproduced showing the grating structure of a pearl-oyster shell, and the structure of parallel layers of an " ear " shell. The absorption spectrum of the latter is also reproduced. In agreement with the observed spacing of the layers under the microscope, it shows the reflection to be of the second order.

III. *The Colours of Labrador Felspar.* (Roy. Soc., Proc. 103. pp. 34–45, April 3, 1923.)—These colours are examined experimentally, and, seen by reflection, arise from two distinct origins: (1) There is specular reflection from tabular inclusions which show the colours of thin plates, and are often as much as 0·2 mm. in dimensions. These are distributed parallel to one of the cleavages. (2) There is diffuse reflection from a plane about 15° away from the cleavage above-mentioned. This is the source of the striking colours which ordinarily excite attention. When the diffuse reflecting plane is examined microscopically, under conditions which ensure that the light only comes from a very thin stratum, it is found that the plane of reflection is discontinuous or patchy. The patches are of irregular outline. The diffuse character of the reflection is accounted for by the small diameter of these reflecting surfaces, regarded as independent optical apertures. Their size (0·005 mm.) accounts approximately for the angular diameter of the diffuse image of a point source seen by reflection, if we regard this as a diffraction disc. This explanation requires that the reflecting patches, though parallel, should not be strictly co-planar, but distributed at random in depth. The colour of the reflection is not sharply limited to special regions of the spectrum, and it appears that the colour can be explained by the interference of streams of light from the two surfaces of each patch. The patches may be fissures in the material, and there is evidence that their thickness is not absolutely uniform. The brightness of the colour is explicable by the large number of reflecting patches adding their effects, without definite phase relation, such as would give rise to regular interference. There is no reason whatever for supposing that reflection from twin planes has anything to do with the colour, though the coloured material itself is often stratified in accordance with the twinning. Microphotographs of the structure, giving rise to the specular and diffuse coloured reflections, are reproduced.

IV. *Iridescent Beetles.* (Roy. Soc., Proc. 103. pp. 233–239, May 3, 1923.) It is shown that some of the iridescent beetles which have striking metallic colours show band systems in the spectrum of the reflected light. Two such spectra are reproduced. The first, from Pelidnota sumptuosa, shows a central maximum, bordered on either side by subordinate maxima in exactly the way taht reflection from a quite uniformly spaced assemblage of thin plates would require. The number of planes calculated to be required in this case is no less than 34. A Lippmann film shows a similar spectrum. The second spectrum is from one of the golden beetles, Callodus parvulus. The bands are accounted for on the supposition of two assemblages, each consisting of several reflecting planes, the distances between the assemblages being about 8. This would result in a series of equally spaced bands over a limited range of the spectrum as observed. The possibility of either of these spectra being produced on the alternative theory of surface reflection is discussed, and found to require a number of special suppositions, which seem very difficult of acceptance.

H. H. Ho.

1828. *Colorimetric Experiments.* **O. Meissner.** VII. (Phys. Zeits. 22. pp. 268–271, May 1; 641–643, Dec. 1, 1921; and 24. pp. 213–215, May 15, 1923.)—The author supports Ostwald's colour theory [Abstracts 97 and 848 (1920)]. In the first paper he replies to criticisms by K. W. F. Kohlrausch [Abstract 70 (1921)], and describes his method of testing colour filters. The second paper describes determinations, made in 1919 and 1922 in daylight and in gas light, of the colours of leaves (trees and shrubs) and of their colour changes with the season. The third paper discusses Ostwald's colour triangle, the corners of which are W (white point), S (black point or grey scale) and R (the colour of purity $r = 100$). RW is the line of bright clear colours, RS that of dark clear colours; the parallels to RW and RS are the isomelanic or isoleucic lines and the parallels to WS the isokatharic lines (of equal purity). By constructing similar triangles on the lines WS and RW as bases, and further, by rotating the triangle RWS about its base WS, the author obtains his mirror images of the colour triangle and his colour double-conoid which, though not practically realisable, are utilised for his considerations.

H. B.

1829. *Loss of Colour in Objects Exposed to Light.* **S. F. Harmer.** (Roy. Soc. Arts, J. 71. pp. 144–149; Disc., 149–153, Jan. 12, 1923.)—A subject of special practical importance in museums. The author investigates the effects of different common methods of illumination on the fading of colours produced by pigments and whether protection is afforded by using tinted glasses as violet and ultra-violet screens. The pigments used are fugitive pigments, aniline dyes, and other artists' pigments, with organic pigments in the skin-derivatives of animals. Russell and Abney found that fading (*a*) is due to the action of light, not to that of moderate heat, (*b*) does not occur *in vacuo* in the absence of oxygen and moisture, and that (*c*) the rays at the violet end of the spectrum are the most effective. The second result indicates a chemical process, and Abney believed that fading is due to the action of ozone. The author describes two series of experiments lasting over seven years; in the first series the maximum exposure given is 1030 days, in the second 1485 days. Direct sunlight, diffused daylight, and light from an incandescent filament lamp are used as illuminants, and in each case the effects of passing the light through various glasses possessing different absorptions in the blue-violet and ultra-violet are determined. Confirming (*a*) a control set of specimens completely protected from light by blackened glass remained unaltered after three years, even though the blackened glass became heated in direct sunlight. Results from specimens kept in compartments with calcium chloride indicate that the additional dryness of the air affords some protection to the colours, and the author does not doubt the conclusion of Russell and Abney. It is generally believed that while a water-colour picture is liable to fade on exposure to light, an oil-painting is improved. The author finds that a pigment used as a water colour fades more rapidly than the same pigment used as an oil colour, but that all pigments are not protected by the oil medium. Diffused daylight is roughly six times as injurious as electric light, while direct sunlight is from twenty to seventy times as injurious as diffused daylight, though little importance is to be attached to these figures. In diffused daylight the most fugitive colours are almost completely bleached, but the least fugitive remain unaffected. As regards the glasses, the general result is found that even the best of the glasses merely delays fading. There are indications that a certain intensity or quality of light is required to initiate the process of fading, for certain pigments which fade in direct sunlight show no perceptible change after four years in diffused daylight or electric light. If the light is capable of starting the process it appears that the action is cumulative. T. H.

1830. *Time Lag in Vision.* **F. L. Hopwood.** (Phys. Soc., Proc. 35. p. 214, June, 1923.)—An experiment is described illustrating this effect. W. R. C.

1831. *Colour Vision.* **W. Peddie.** (Phil. Mag. 45. pp. 1058–1062, May, 1923.)—The author considers that the tri-chromatic theory of vision must be regarded as being physically established on a firm basis. Helmholtz has pointed out clearly that it is utterly impossible to discriminate the absolute fundamentals by means of observations on colour mixture. This conclusion is dependent only on the linearity of the law of colour mixture and is quite independent of any assumption as to trichromasy. The statement applies equally to Edridge-Green's multichromatic or non-elemental postulates. The relation of luminosity to colour is argued by the author against Edridge-Green's point of view. Some colour-blind persons who object to a normal white equation cease to do so when the intensity of the comparison white is raised to such an extent that it appears much too bright to the normal eye. Helmholtz insisted on the merely illustrative value of the special hypothesis regarding the mechanism of vision, and even said that a triple set of nerve fibres might be inessential. T. C. H.

1832. *Theory of Vision.* **O. Emersleben.** (Zeits. f. Physik, 15. 2 and 3. pp. 180–183, 1923.)—A critical discussion of Schanz's quantum theory of vision [Abstract 1103 (1923)]. A. D.

1833. *Change of the Plane of Polarisation of Light in a Rotating Medium.* **E. Fermi.** (Accad. Lincei, Atti, 32. pp. 115–118, Feb. 4, 1923.)—Mathematical investigation of the effect of rotation of a transparent medium on the plane of polarisation of light traversing it. Supposing that a transparent medium rotates round an axis and that light rectilinearly polarised passes through the medium parallel to the axis; instead of a species of rotatory power of magnitude $\frac{\omega n}{c}$ (where ω = angular velocity, c = velocity of light, and n = index of refraction of the medium) being produced, it is found that this quantity must be multiplied by a coefficient precisely equal to that of Fizeau, *viz.* $\frac{n^2-1}{n^2}$, so that the rotatory power $= \frac{\omega n}{c} \cdot \frac{n^2-1}{n^2}$. J. J. S.

1834. *Action of Molybdic Acid on the Rotatory Power of Tartaric and Malic Esters.* **E. Darmois.** (Comptes Rendus, 176. pp. 1140–1142, April 23, 1923.)—Aqueous solutions of methyl or ethyl tartrate or ethyl malate, with molybdic acid or a molybdate undergo mutarotation, especially when the temperature is raised, the rotatory power increasing very

greatly. In the case of ethyl malate and ammonium molybdate, ammonium dimolybdomalate [Abstract 1358 (1928)] was isolated from the product, proving that the ester is hydrolysed during the mutarotation.
T. M. L.

1835. *Optical Activity of Cubic Crystals of Sodium Chlorate and Bromate.* **C. Hermann.** (Zeits. f. Physik, 16. 2. pp. 103–134, 1923.)—Oseen [Abstract 188 (1916)] and Born have suggested that rotatory power need not depend on a spiral structure in the molecule, but can be explained if (*a*) the oscillators are coupled to one another, and (*b*) the molecules or space-lattices are asymmetric. The natural rotations of these two regular crystals, which disappears on dissolution, appeared particularly suitable for mathematical investigation, on account of the regularity of the lattice and the absence of rotatory power in the constituent ions, as well as the fact that only one index of refraction needs to be considered. There is, however, some uncertainty as to the structure of the crystals, since the models of Kolkmeijer and of Dickinson show the group of three oxygen atoms as lying nearly in a plane with the chlorine or bromine with which they are associated, whereas Vegard makes the four atoms form a substantial tetrahedron. Calculations based on the coplanar arrangement of the anion give in the case of sodium bromate a very fair agreement with the observed rotations over the range of wave-lengths from 4047 to 7621, although the observed and calculated curves definitely cross one another. In the case of sodium chlorate, the order of magnitude of rotations is still correct, but the calculated values are smaller throughout, ranging from about 50 to 70 per cent. of the observed values. It is suggested that in this case Vegard's model is probably more correct, and that the displacement of the halogen from the plane of the oxygen atoms may account for the larger derivations here observed.
T. M. L.

1836. *Optical Rotations of the Sugars. Part II. Methyl Pentoses and Glucosides.* **J. G. Maltby.** (Chem. Soc., J. 123. pp. 1404–1409, June, 1923.)—Regularities such as those shown by the pentoses and hexoses [Abstract 311 (1923)] are shown also by the methyl pentoses and glucosides.
T. M. L.

1837. *Double Refraction Due to Motion of a Vanadium Pentoxide Sol.* **R. H. Humphry.** (Phys. Soc., Proc. 35. p. 217; Disc., 217–218, June, 1923.)—Particulars are given of the preparation of vanadium pentoxide sol for this purpose.
W. R. C.

1838. *Zeiss Stereoplanigraph.* **O. v. Gruber.** (Zeits. Instrumentenk. 43. pp. 1–16, Jan., 1923.)—Gives a detailed description of the theory of this instrument and of its construction and extent of application. The paper is too long and detailed to admit of being usefully abstracted. A further paper on the adjustment of the instrument and method of use is promised.
J. W. T. W.

1839. *Brace Half-Shadow Compensator.* **Nina Wedeneewa.** (Zeits. Instrumentenk. 43. pp. 17–24, Jan., 1923.)—Szivessy has described (Zeits. f. Phys. 6. p. 311, 1921) a new form of Brace compensator, substituting for the mica plate a sheet of glass under strain so as to obtain a variable half-shadow angle. The author considers that this arrangement of the apparatus is inferior in sensitivity to the original Brace instrument which, she shows, may be used as a variable half-shadow instrument analogous to the Lippich polariser. [See W. E. Williams and F. Twyman, *Dictionary of Applied Physics,* Vol. IV, p. 482.] The increase of sensitivity obtainable by using the half-shadow plate at small angles of azimuth is, however, limited by the rapid decrease of field brightness. The relation between the accuracy possible with the instrument, and the phase difference produced by the compensator is therefore investigated, and it is found that very small phase differences should not be used, the minimum suggested being 30°. J. W. T. W.

1840. *Investigations with Radiometers. Part II. A New Measurement of Radiation Pressure.* **W. Gerlach** and **A. Golsen.** (Zeits. f. Physik, 15. 1. pp. 1–7, 1923.)—Previous work by Lebedew using vacuum radiometers and by Nichols and Hull, who employed pressure instruments, is first briefly but critically examined. Experiments are then described of a fresh determination of radiation pressure with a vacuum apparatus, details of which are supplied. In a vacuum of 10^{-6} to 10^{-7} mm. Hg a constant residual deflection of the radiometer was found, indicating a definite radiation pressure. This deflection is found to be proportional to the incident energy, but independent of the wave-length of the radiation. The radiation pressure hereby determined agrees with the theoretical value. [See Abstract 1566 (1923).] H. H. Ho.

1841. *Dispersion and Brightness of Direct Vision Prisms.* **H. Krüss.** (Zeits. Instrumentenk. 43. pp. 126–133, April, and pp. 162–169, May, 1922.)—The work of Amici, Janssen, Browning, etc., on optical attempts to avoid dispersion, is first very briefly mentioned, following which comes an economic discussion of the problem as to whether a threefold or fivefold prism combination offers the greater advantage, since the greater dispersion is balanced by the loss of light and also by the price. The problem is regarded from the standpoint of the different wave-lengths in the spectrum, and the various kinds of glass available. The best conditions for the simple pocket spectroscope and for the stellar instrument are reviewed. The paper teems with technical details for which the original must be consulted. H. H. Ho.

1842. *The Law of Photochemical Equivalence and the Dry Plate. Part II.* **J. Eggert** and **W. Noddack.** (Preuss. Akad. Wiss. Berlin, Ber. 15. pp. 116–122, 1923. From the Reichsanstalt.)—Having shown [Abstract 224 (1922)] that the law of photochemical equivalence is applicable to the photographic dry plate, as far as order of magnitude is concerned, the authors confirm by further experiments with improved methods that, when dry plates are illuminated by monochromatic light (436, 405, 365 $\mu\mu$) and both the radiated energy received and the absorption of the plate are measured, allowing for the gelatin absorption, and the silver formed by the photolysis is determined, then one atom of silver is found to be liberated per $h\nu$. A quartz-mercury and a "Nitra" lamp were used; details of the measurements are given. The law, it is pointed out, does not hold for very strong illumination, because in that case the atoms of silver and of bromine may recombine when the gelatin acting as acceptor contains bromine. H. B.

1843. *Photochemical Transformation of Fluorescing Colour Solutions.* **P. Pringsheim.** (Zeits. f. Physik, 16. 1. pp. 71–76, 1923.)—Photochemical highly sensitive and relatively unsensitive eosin solutions possess identical light absorption and fluorescence capacity. In the sensitive solutions fluorescence and chemical reaction is produced by light of the same spectral region, and both processes can be excited by pure monochromatic radiation. J. J. S.

1844. *On the Sensitiveness of Photographic Plates containing Mercury Salts.* **G. Athanasiu.** (Comptes Rendus, 176. pp. 1389–1392, May 14, 1923.)—A previous use by the author of mercury salts [see Abstract 2317 (1922)] for actinometers has induced him to make the present study of the sensitiveness to light of the halogen salts of mercury in the various parts of the spectrum. Lüppo-Cramer had previously worked on this subject, but abandoned it owing to the lack of sufficient sensitivity, mercury chloride giving no effect whatever. In the present investigation plates of Hg_2Cl_2 and Hg_2Br_2 were found definitely to be sensitive, but the range was limited to the ultra-violet part of the spectrum. Brief experimental details are given with a table of results. Plates of HgI_2 are found to be the most sensitive with a maximum in the green, after which it decreases quickly and uniformly with the length of the wave. For all radiations studied mercury salts are less sensitive than those of silver. Their use, however, as orthochromatic plates without screen should be very convenient for work which demands less sensitiveness in the blue and violet than in the yellow and green. Plates of Hg_2I_2 are less sensitive than those of HgI_2, being acted on by the green ray 5460, but not by the yellow 5790. The sensitiveness is a maximum towards 3300. The region for Hg_2Br_2 commences a little before 4046 with a maximum at about 3130, and the plates are remarkable for their fineness of grain. Plates of Hg_2Cl_2 are least sensitive, the maximum being towards 2967, but activity commences at 3650, although in the ultra-violet they are more sensitive than plates of Hg_2Br_2. Plates of Hg_2Br_2 and Hg_2Cl_2 being only sensitive for radiations which are strongly absorbed by glass, it becomes extremely difficult to obtain positive results when glass is in use, a fact which explains the failure of Lüppo-Cramer. H. H. Ho.

1845. *Quantum Theory of Photographic Exposure. Part III.* **L. Silberstein.** (Phil. Mag. 45. pp. 1062–1070, May, 1923.)—The purpose of this paper is, first, to take account of the absolute energy values of the exposures used in the experiments described in the first two papers on this subject, which values are since measured, and, in the second place, to deduce from the fundamental formula the integral or "density" formula for a certain type of emulsions and to compare it with the experimental results recently obtained with X-rays. The treatment of the first point affords a good opportunity for amplifying the proposed theory in a sense already hinted at in the second paper [see Abstract 666 (1923)]. In that paper it was mentioned that possibly not the whole but only some fraction "ϵ" of the area "a" of a silver halide grain is "vulnerable," *i.e.* ready to become developable on being hit by a light dart carrying a quantum of energy of sufficiently high frequency, and that if "n" be the unknown number of such darts impinging per unit area of the plate the product $n\epsilon a$ can be determined from microphotographic experiments, and therefore also $n\epsilon$ but not n itself. Whether at all and how much the coefficient ϵ, which can be taken as the measure of sensitivity of a given material differs from unity can only be decided by measuring the absolute energy-value of the exposure given to the plate. In the experimental emulsion used in these observations ϵ on an average is only about 1/100,000 and certainly not more than 1/10,000 of the area of a grain of this emulsion which would be sensitive to light. The theory is developed which considers the sensitive part of the area of a grain, instead of being all in a lump, to consist of a number of separate vulnerable or sensitive spots each of area ω and distributed among the individual grains not equally but haphazardly. The necessary and sufficient condition for a grain to be made developable will now be that at least one of its spots should be hit by at least one light dart of a sufficiently short wave-length. Formulæ are obtained for finding the value of κ, the average number of spots per gran, and also of ω. A density formula for ideally "exponential" emulsions is also developed. A table is given in which a comparison is made of some X-ray exposure curves and theoretical results obtained by using the very simple formula here given. A. E. G.

1846. *Stability of Phosphorescence Centres. Parts I and II.* **H. Kuppenheim.** (Ann. d. Physik, 70. 2. pp. 81–112, and 113–120, Jan. 31, 1923.)—Experiments are described on the decay of phosphorescence bands of calcium-bismuth phosphores up to a short time after the excitation ceases and on the influence of temperature on this decay. Confirmation is obtained of the diminution in the period of duration of all the phosphorescence centres by rise of temperature. Together with this there occurs a diminution in the number of the centres, the smaller ones being destroyed first and the larger ones at higher temperatures. If the upper limiting temperature is not surpassed, the *d*-centres are regenerated in their original form and distribution when the temperature is lowered again. Various earlier observations on the constitution, etc., of the bands, and on the stability of the centres over a wide range of temperature are confirmed. The influence of pressure on the *m*-centres and on *d*-centres of different magnitudes is similar, all the centres being destroyed in the same numerical proportions. Investigation of various forms of destruction by pressure confirms Lenard's view of the manner in which pressure acts on the centre molecules and also supports the supposition that energy-insulating spaces occur in the centres. T. H. P.

1847. *Polarised Fluorescent Light from Dyestuff Solutions. Part II.* **S. J. Wawilow** and **W. L. Lewschin.** (Zeits. f. Physik, 16. 2. pp. 135–154, 1923.)—This investigation is a continuation of work previously published [see Abstract 1874 (1922)]. Twenty-six dyestuffs have been examined from which it appeared that for all dyestuffs, which in aqueous solutions emitted bright fluorescent light, the fluorescence was practically non-polarised (the measurements gave 0 to 3 %). Those colours which are feebly fluorescent in water emit strongly polarised light (about 30 %) in agreement with Weigert's experiments. In glycerine all the dyestuffs examined emit strongly polarised fluorescent light whose degree of polarisation (about 35 %) is practically the same for all dyestuffs with the exception of 2 rhodamines. Many experiments were carried out which made clear the dependence of the phenomenon on the viscosity. By altering the latter, the degree of polarisation could be varied from zero to a definite maximum limit, which could not be exceeded under any experimental conditions. The dyestuffs rhodamine B extra and rhodamine G extra behave in many respects essentially different from all other colours investigated. In such colloidal viscous media as collodion, celluloid in acetone, and gelatine in water, the dyestuffs behave simply as in alcohol, acetone, or water. By this means real and apparent viscosity can be distinguished. The degree of polarisation is independent of the wave-lengths of the fluorescence spectrum, and is always with natural light greater than half the degree of polarisation when polarised light is used. Under the assumption of the proportionality of the energy of the secondary radiation with that of the primary, the formula $p_n = p_p/(2 - p_p)$ has been derived, where p_n is the degree of polarisation for natural light and p_p for polarised light, and this expression corresponds well with the measurements. From this standpoint the results of investigators in the field of fluorescent gases and vapours appear inexplicable. The classical conception of the polarisation phenomenon is sketched but without reference to frequency changes in the fluorescence mechanism, and affords a satisfactory explanation of many observed facts. H. H. Ho.

1848. *Absorption in Iodine and other Vapours.* **K. Vogt** and **J. Koenigsberger.** (Zeits. f. Physik, 13. 5. pp. 292–311, 1923.)—Results are given of measurements of the continuous absorption, absorption bands, and lines of the vapours of iodine, bromine, and nitrogen peroxide at various temperatures, thicknesses, and pressures. The continuous absorption region of iodine vapour broadens as the temperature rises, the maximum absorption changing but little in position but becoming less in degree. As the temperature is raised above 600° and dissociation proceeds, selective and band absorption become weaker, the resulting spectrum resembling multiple line spectra. Hence band and selective absorption are peculiar to the molecule or to a condition dependent on the formation of molecules. Beer's law, according to which the absorption coefficient is proportional to the density, holds for iodine vapour for selective continuous absorption, for the band spectrum as a whole, and for the separate lines, only up to the density of 5×10^{-5}. For bromine the limits given by Ribaud are confirmed. Addition of air increases the absorption slightly on the short wave-length, and considerably on the long wave-length, side of the maximum. The observed selective absorptions agree well with the calculated absorptions on the short, but not on the long wave-length sides of the maxima. Only about 1 per cent. of the total molecules present take part in the selective absorption.

At low densities the band spectrum of iodine vapour exhibits a channelled appearance, caused by differences in intensity between the separate absorption lines. With bromine at high densities and with iodine, bromine, and nitrogen peroxide when compressed by means of foreign gases, the separate absorption lines become broadened, this effect being regarded as the result of the molecular collisions; the rotation Doppler effect is negligible in amount. T. H. P.

1849. *Absorption of Potassium Vapour at High Temperatures.* **A. L. Narayan** and **D. Gunnayya.** (Astrophys. J. 57. pp. 191–192, April, 1923.)—When investigating the optical properties of non-luminous potassium vapour it was found that at high temperatures, about 950° C., this vapour absorbs λλ4641, 4642, the first members of the combination series (1*s*–3*d*) [see Abstract 1608 (1922)]. It is considered that this, with other experiments, points to the conclusion that the method whereby the rotational quantum numbers have been assigned requires reconsideration. J. J. S.

1850. *Absorption of Potassium Vapour.* **A. L. Narayan** and **D. Gunnayya.** (Phil. Mag. 45. pp. 831–834, May, 1923.)—The absorption of potassium vapour was studied at various temperatures, the substance being enclosed in a steel tube 30 in. long and 1 in. in diameter, closed at the ends with quartz plates. The source of light used was the carbon arc and the temperature of the metal, introduced in the form of strips into the middle of the tube, was raised to different temperatures up to 950° C. On heating, first the absorption lines at the red end appeared and next the accompanying channelled spectrum. With increase of temperature and consequent increase of the density of the vapour the higher members of the Balmer series also developed. Then it was found that the first two or three pairs of this series were immersed in a band spectrum which was in reality the accompanying channel spectrum subsequently developed into a dark band. Great increase in the vapour density was necessary to bring out the higher members of the series, the temperature being between 750° and 800° C. At this temperature the Balmer series could be extended to 30, and the only further effect observed on raising the temperature to 950° C.—the highest attainable with the arrangement used—was the suspected slight trace of absorption in the first members of the diffuse series. A table is given of the wave-lengths of the principal Balmer series lines observed from $m = 11$ to $m = 29$, and also the wave-lengths of 14 bands measured in the red channelled spectrum. Photographs of the spectra are given. J. J. S.

1851. *Emission and Absorption of Halogens in the Visible and Ultra-Violet Regions.* **A. L. Narayan** and **D. Gunnayya.** (Phil. Mag. 45. pp. 827–830, May, 1923.)—The emission spectra of bromine and chlorine are line spectra, the nature of which depends on the intensity of discharge and the temperature of the tube. With increase of intensity some lines are reinforced and others disappear. As regards absorption spectra the halogen vapours give a banded spectrum in the yellowish-green region between 5800 and 5000 Å.U., the bands being sharp on the violet side and fading away towards the red end. General absorption begins at the ultra-violet end and extends up to 4900 Å.U. as the pressure of the gas is increased. With increase of pressure the bands become darker and a few more appear against the red end. At great pressures the general absorption band extends up to the green, where the banded spectrum begins. The absorption of bromine gradually increases from 30° to about 600° C., at which it absorbs almost the whole of the ultra-violet up to 2000 Å.U. After this the absorption falls and the vapour is increasingly transparent to ultra-violet radiations. In the case of chlorine the absorption increases slightly towards the red end with rise of temperature, maximum temperature in the experiments being 800° C. With iodine absorption increases as the temperature rises up to 300° nearly. At this temperature the ultra-violet up to 3250 Å.U. is completely absorbed, and above it the vapour again transmits the ultra-violet radiation. Photographs of the spectra show that with the greatest quantity of chlorine, absorption at ordinary temperatures did not extend above

2750 Å.U., with bromine not beyond 3450 Å.U., and with iodine not beyond 4100 Å.U. The emission and absorption spectra of these vapours are not complementary: this may be due to different complexities of molecular structure in the two cases. Moreover, Beer's law does not seem to hold good in the case of these vapours. J. J. S.

1852. *The Measurement of Standard Wave-Lengths.* **K. Burns.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 419–437, June, 1923.)—A summary of methods and results of recent work on the determination of standard wave-lengths, with references to papers published during the last few years. J. J. S.

1853. *Energy Distribution in the Balmer Series.* **R. Beatty.** (Phil. Mag. 45. pp. 1080–1081, May, 1923.)—A discussion of results obtained by Lasareff [see Abstract 1320 (1923)] for the relative amounts of energy emitted per second in the first three lines of the Balmer series of hydrogen, compared with results of experiments by Jolly and by Beatty. The wide differences between the results are attributed to the mutual interference of the atoms, and it is contended that unless this effect can be eliminated, and the many other incalculable factors, such as pressure dealt with, estimations of the numbers of atoms giving rise to each line cannot be based on intensity measurements. A. C. M.

1854. *On Spectra Associated with Carbon.* **T. R. Merton and R. C. Johnson.** (Roy. Soc., Proc. 103. pp. 383–395, June 1, 1923.)—In the present investigation an attempt has been made to study the effect of the presence of helium upon the band and line spectra of carbon, and in addition to find the conditions under which the different spectra can best be experimentally isolated. Experimental details are described with tables of data and illustrative plates. The Swan spectrum, the Ångström bands, and the CH-bands [see Abstract 1211 (1916)] are dealt with briefly. With regard to the high-pressure bands, the experiments are in accordance with Fowler's assignment of this spectrum to CO, but in this case as with other carbon bands the discharge conditions are of fundamental importance in determining the spectrnm. The appearance of the comet-tail bands in high-pressure helium is remarkable and shows that in itself the total pressure is not the determining factor, although it is at the same time clear that the partial pressure of carbon has to be extremely small in order that the comet-tail bands may replace the Swan and Ångström spectra. The change of the intensity distribution in the presence of helium presents a problem for which there is no obvious solution, but its practical importance is evident in the reproduction of celestial spectra in the laboratory. The triplet band system seems to belong to the same category in requiring a large quantity of helium for its isolation, and differs only from the comet bands in requiring the presence of hydrogen; but in view of the fact that the mutual effect of gases appears to be more complex than can be explained by the mere formation of chemical compounds, it would be premature to assign the triplet system definitely to a compound of carbon and hydrogen. The new carbon line spectrum also appears to be associated with the presence of an excess of helium, and while the authors offer no theoretical explanation of the modifications in the spectra which are produced by the addition of helium, its action may perhaps be described, from a purely experimental point of view, as enabling discharges to pass when the gases with which it is mixed are present in such small quantities that if the total pressure in the tube were equal to their partial pressure it would be impossible to pass a discharge. This seems to offer a method of obtaining spectra appropriate to extremely low pressures. H. H. Ho.

1855. *The Line Spectrum of Chlorine in the Ultra-Violet (Region λ3354–2070 Å.).* **W. Jevons.** (Roy. Soc., Proc. 103. pp. 193–204, April 3, 1923.)—The lack of success in the analysis of the Cl-line spectrum is opined by the author to be due to the incompleteness of the experimental data. Paulson has discovered certain constant differences of wave-number, but in the absence of any recognition of series, these differences are at present of restricted significance. Observations with Cl discharge tubes present difficulties (to which Kayser, Hagenbach, and Konen have drawn attention) caused by the chemical activity of Cl. Only glass discharge tubes have been used hitherto, and the quartz ultra-violet region thereby sacrificed. Previous work on the Cl spectrum is briefly referred to, and the present investigation extends previous data by the use of the condensed discharge through Cl tubes either of quartz or of glass (with a quartz window) while attempting to recognise the lines due to impurities (either originally present in the Cl or arising from its actions on electrodes, cement, etc.). Tables are given recording about 200 lines between λ3354 and 2070 Å., together with the effect of capacity on the estimated intensities of more than one-half of them. Experimental details are given in brief, and an extended description included of the means taken to identify lines due to impurities. The following lines attributed by Exner and Haschek to Cl have not been observed: 3291·1 (2 *nb*), 3261·6 (1 *nb*), 3248·5 (1 *nb*), 3221·1 (2 *nb*), 2960·5 (1 *nb*), 2936·7 (1 *nb*), 2928·8 (1 *nb*). The line at 3129·5 (1 *nb*) is probably due to O. About 70 of the 201 lines recorded by Eder and Valenta are found to be involved in possible doublets and triplets. There is, however, no apparent regularity in the intensities of the lines involved in the pairs and triplets given by Paulson. Some views of Hicks are recorded in support of the idea that the constant differences observed may have a real significance in a series analysis of the Cl spectrum. H. H. Ho.

1856. *Structure of the Band Spectrum of Helium. Part II.* **W. E. Curtis.** (Roy. Soc., Proc. 103. pp. 315–333, May 3, 1923.)—In a previous paper [Abstract 1606 (1922)] an account was given of the structure of the three helium bands $\lambda\lambda$6400, 5730, 4546. The present paper deals with the internal structure of the remaining bands, which have been previously dealt with by Fowler [Abstract 557 (1915)]. Wave-length tables and least-squares empirical formulæ are given for the constituent series of each of seven bands. The structure of the bands is, in the main, in agreement with the requirements of the quantum theory, but some important discrepancies are noted and discussed with reference to the half-quantum hypothesis advanced by Kratzer [Sitz. d. Bayer. Akad., p. 107, March, 1922]. A graphical method was used to obtain the values of the moments of inertia of the molecules concerned, and the values obtained were used to verify theoretical conclusions. Several perturbations, the first examples in this spectrum, are noted, and their significance is discussed. A new combination principle was found to be obeyed. $R'(m) - P(m+1)$ was found to be a constant for bands of the same series and for the same value of m. A. W.

1857. *On the Spectrum of Neutral Helium.* **C. V. Raman** and **A. S. Ganesan.** (Astrophys. J. 57. pp. 243–247, May, 1923.)—The paper is a criticism of Silberstein's formula for the lines of neutral helium, *viz.* $\nu = 4N \left\{(1/n_1^2 - 1m_1^2) + (1/n_2^2 - 1/m_2^2)\right\}$ where n_1, n_2, m_1, m_2 are 4 independent integers such that $m_1 > n_1$ and $m_2 > n_2$. As objections to the validity of the formula, it is pointed out that the ionising potential computed by means of this formula does not agree with that given by experiments; that no definite principle of selection has been given to indicate observable lines; that there is no arrangement of lines as regards series relationship, division into singlet and doublet systems, or of intensities. The difference between the actual and the calculated frequencies is shown to be the same as that to be expected on the assumption that the coincidences are purely accidental; and the same frequencies can be obtained with different sets of numbers. The formula has therefore no physical basis or significance in the opinion of the authors. H. H. Ho.

1858. *On the Spectrum of Helium; a Rejoinder to C. V. Raman and A. S. Ganesan.* **L. Silberstein.** (Astrophys. J. 57. pp. 248–250, May, 1923.)—The author here considers the objections raised against his formula for the spectrum of neutral helium by Raman and Ganesan [see preceding Abstract]. He disclaims ignoring the fact that the observed lines fall into certain definite series, and points out that the formula covers 23 of the 30 so-called combination lines. The author states that a discussion of the ionisation potential was purposely omitted from his original paper, since the mutual relation of the electrons in the normal state of the atom is still an open question. He has preferred to deal with it in a separate paper. In order to show that the coincidences of lines are fortuitous, he computes that for $3 \leqq n \leqq 8$ and $4 \leqq m \leqq 20$ the theoretical number of lines in the interval $19{,}800 \leqq \nu \leqq 37{,}800$ is 631. Of these, 44 coincide with observed lines, of which there are 96 in this interval. The probability that these coincidences are accidental is of the order 10^{-13}. In fine, the "fortuitous" hitting of these 44 lines under the said circumstances is as improbable as making 40 "heads" in succession in tossing a coin.

H. H. Ho.

1859. *Infra-Red Spectra:* (1) *Infra-Red Emission Spectra of Various Substances, and* (2) *Infra-Red Absorption Spectra of Benzene and some of its Compounds.* **J. E. Purvis.** (Cambridge Phil. Soc., Proc. 21. pp. 556–565, June 15, 1923.)—It has been shown by Pauer, Hartley, and Purvis that benzene, chlorobenzene, and bromobenzene, as liquids, or in solution, show a number of wide diffuse bands in the ultra-violet, whereas, in vapours, each of these bands breaks up into a series of narrow fine lines. The present author showed [Abstract 710 (1912)] that iodobenzene exhibited no such selective absorption either as a liquid or as a vapour. The absorption spectra of these substances have now been investigated in parts of the infra-red region. Rays from an entrance slit are reflected by a plane mirror on to a concave mirror, where they are rendered parallel, and reflected back over their original path by the silvered back surface of a 30° prism of rock-salt. The rays from various parts of the infra-red spectrum are then received on a thermopile of bismuth-silver, and their intensities compared by the deflection of a sensitive galvanometer. Various sources of radiation, *e.g.* a Nernst "heater," a Nernst "filament," a Welsbach light, were investigated, and curves drawn showing the deflection of the galvanometer at various wave-lengths from 1 μ to 12 μ. An absorption cell was employed to contain the solutions, consisting of two polished rock-salt plates 0·165 mm. apart. The vapours were contained in a tube 120 mm. long, the ends being covered with polished rock-salt plates. The curve for C_6H_5I is similar to those of C_6H_5Br and C_6H_6 (liquids) but is shifted towards the visible spectrum. The liquid benzene curve shows three well-marked bands at 1·7μ, 2·08μ, and 2·49μ, and these bands show signs of division when the radiations pass through the vapour. This division of the liquid bands into a series of separate vapour bands is also observed for chlorobenzene, bromobenzene, and iodobenzene The liquid band (for benzene) at 1·7 μ was investigated in greater detail, and a large number of readings between 1·5 μ and 1·9 μ gave divisions of the band when the benzene was in the form of vapour. T. B.

1860. *Properties of Resonance Radiation and Excited Atoms.* **K. T. Compton.** (Phil. Mag. 45. pp. 750–760, April, 1923.)—In accounting for spectral lines, for their variation in intensity with different conditions of excitation, and for phenomena of cumulative ionisation, attention has recently been called to the existence of atoms and molecules in various conditions of partial or complete ionisation. In recent papers [Abstract 538 (1923)] the author discussed the two ways in which atoms may be put into the excited, or partially ionised, state. In the present paper certain important properties of resonance radiation are pointed out, and attention is called to the bearing which these may have on the problem of the existence of atoms in various excited states. It is shown (1) that the passage of resonance radiation through a gas may be treated as a problem in diffusion, (2) that the number and persistence of excited atoms depends jointly on the average time of activation of an atom and the square of the scattering coefficient of the resonance radiation in the gas, and (3) that the presence of impurities may affect experiments on the properties of resonance radiation by causing its transformation into other wave-lengths to which the gas is more transparent. A. B. W.

1861. *On the Influence of Magnetic Fields on the Polarisation of Resonance Radiation.* **R. W. Wood** and **A. Ellett.** (Roy. Soc., Proc. 103. pp. 396–403, June 1, 1923.)—The emission of polarised light by fluorescent sodium and iodine vapours discovered by R. W. Wood could not be obtained for the much simpler type of emission which occurs when a gas or vapour re-emits without change of wave-length the energy which it abstracts from the incident beam. Lord Rayleigh's results for the resonance radiation of mercury-vapour which appears to show fairly strong polarisation increasing as the exciting radiation penetrates into the vapour were not confirmed by Wood recently [see Abstract 503 (1923)], the polarisation appearing of full strength right up to the entrance window of the exciting beam. A possible explanation of Lord Rayleigh's results is now offered, it being shown that in the case of the resonance radiation of mercury and sodium vapour strong polarisation of the light can be produced by weak magnetic fields properly orientated, and that the polarisation of the light normally present can be destroyed by a magnetic field in a certain orientation. The field strength necessary for the destruction of the mercury-vapour polarisation is less than one Gauss. Full experimental details are included. The authors believe that a new magneto-optic effect is here to hand, probably connected in some way with the orientation of electron orbits in the magnetic field, the explanation of which, should it be forthcoming, will doubtless shed much additional light on the mechanism of resonance radiation. H. H. Ho.

1862. *The D_2 Zeeman Pattern for Resonance Radiation.* **P. D. Foote, A. E. Ruark,** and **F. L. Mohler.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 415–417, June, 1923.)—The Sommerfeld-Landé interpretation of the anomalous Zeeman effect shows how the complicated patterns may be explained as due to alterations in the atomic energy levels associated with the various spectral series terms. In this paper attention is drawn to a rather curious deduction which follows from the quantum-theoretical interpretation of the phenomenon. A bulb of sodium vapour at very low pressure is supposed to be placed in a uniform magnetic field and illuminated normal to the lines of force by a beam of radiation linearly polarised with the electric vector parallel to the field. The conclusion is drawn that the Zeeman pattern for the resonance radiation under the conditions considered should be a quadruplet instead of a sextuplet. Although the original exciting radiation was polarised parallel to the field, the emitted radiation, as viewed in the transverse effect, should have two components polarised with the field and two polarised at right angles to the field. The latter arise in the light which is circularly polarised in the longitudinal effect. Although the original light is plane polarised and hence can communicate no moment of momentum to the atom, still the atom as a result of the absorption of this radiation is enabled to emit circularly polarised light possessing angular momentum. The source of this angular momentum is the magnetic field. A study of the Zeeman effect for resonance radiation has interesting possibilities. J. J. S.

1863. *Term Structure and Zeeman Effect of the Multiplets.* **A. Landé.** (Zeits. f. Physik, 15. 4 and 5. pp. 189–205, 1923.)—The first part of this paper deals with various rules and relations deduced from experiment on spectral systems. In the second part a mathematical discussion based on models of electron systems is given. While a full explanation is not reached, the principal difficulties of the theory of the Zeeman effect are brought into prominence and indications are given at what points new ways for the satisfactory solution of these difficulties must be attained. J. J. S.

1864. *Stark Effect in Strong Fields.* **H. Newboult.** (Phil. Mag. 45. pp. 1081–1085, May, 1923.)—A suggested correction to the papers by Mosharrafa [see Abstracts 1611 (1922) and 685 (1923)]. The frequency difference is calculated in terms of functions of integers n_1, n_2, m_1, m_2; the correction does not affect the value of the function when $n_1 = n_2$ and $m_1 = m_2$. A. C. M.

1865. *Photoelectric Experimental Test of Planck's Radiation Formula.* **E. Császár.** (Zeits. f. Physik, 14. 3 and 4. pp. 220–225, 1923.)—The author claims priority over E. Steinke [Abstract 900 (1923)], his results having been communicated to the philosophical faculty of the Royal

Hungarian University, Oct. 30, 1922. Since the kathode potential was sufficiently removed from the discharge potential, Elster and Geitel's law of proportionality could be employed. A Lummer-Kurlbaum cylinder was employed as a black body source of illumination, and monochromatic radiation was obtained by means of a Fuess monochromator; the anode of the photoelectric cell was connected with a Muelly quadrant electrometer; the black body, monochromator, and cell were enclosed in a black tent in a dark room; the time taken to charge the electrometer with different illuminations was measured, the temperature of the black body being varied; the darkness effect was negligible. The mean value of c_2 obtained was 14,345 micron degree C, with a relative maximum error of about 3 %; this could be considerably reduced by avoiding the variation of the voltage of the heating current by using a storage battery, by using the compensation method instead of a millivoltmeter to measure the temperature, and by using a thread electrometer. Steinke claims that the relative maximum error of his observations of c_2 is 0·63 %; but the author points out figures in Steinke's tables which give, instead of his value 14,385 for c_2, the values 16,720; 13,574; 15,413; 15,044; 15,233. H. N. A.

1866. *Determination of the Radiation Constant by Westphal's Method.* **K. Hoffmann.** (Zeits. f. Physik, 14. 5. pp. 301–315, 1923.)—The following values have been obtained for the radiation constant σ in the formula for the total radiation of a black body; the dates of publication are given and the numbers are to be multiplied by 10^{-12} to obtain watts/cm.^{2} degrees^4. Kurlbaum, 1898, 5·45; Valentiner, 1910, 5·58; Gerlach 1920, 5·80; Coblentz, 1915, 5·72; Westphal, 1913, 5·57. Westphal's method, which was used by the author, is described in the Ver. d. Deutsch. Phys. Ges. [Abstracts 460 (1913) and 289 (1914)]. The radiating body in Hoffmann's experiment was a massive cylinder of copper, with a spiral groove in which the insulated heating wire was wound. Over the cylinder was passed an accurately fitting copper tube, which was fixed at the lower end by a brass screw. A fine longitudinal hole was bored in the copper tube for the thermo-element, which was thus very near the surface of the mantle tube. The whole radiating body hung in a flask, the walls of which were covered inside with a preparation of lamp-black, and which was evacuated to 1 mm. pressure. It was found that better results were thus obtained than with higher or lower pressures. The flask was surrounded with ice, and the input into the heating wire in watts and the temperature of the mantle tube were determined with the greater part of the mantle surface covered with a special lamp-black preparation. In a preliminary set of experiments the emission of the polished cylinder and of the lamp-black surface were carefully studied by comparison with a "black body." The original paper should be referred to for the necessary corrections; the value obtained was $(5{\cdot}76_4 \pm 0{\cdot}052) \times 10^{12}$ watts/cm.^{2} degrees^4, which differs very little from those of Gerlach and Coblentz obtained by other methods. H. N. A.

1867. *The Hypotheses of Quantum Emission in Black Body Radiation.* **E. Császár.** (Zeits. f. Physik, 14. 5. pp. 342–354, 1923.)—The object of the author is to reduce the discontinuities in the hypothesis of quantum emission. According to Planck, the emission of the oscillators is discontinuous throughout the whole energy region, from 0 to ∞; the author assumes that for all oscillators there is a critical energy limit (analogous to the critical temperature), above which the oscillators alter their behaviour. Absorption takes place continuously throughout; this is also true of the emission, except in the energy region between 0 and $(n+1)\epsilon$ [including $(n+1)\epsilon$]. In this region an oscillator can only emit energy at the moments when its energy is a whole multiple of the energy quantum $\epsilon = h\gamma$; in each case it emits the whole of its energy. A series of new radiation formulæ are derived, which agree pretty closely with Planck's formula when $n = \infty$. When $n = -1$ there is no discontinuity, and Rayleigh's formula is obtained; $n = 0$ gives the formula of Bauer–Moulin–de Boissoudy. The formula of Nernst and Wulf can also be brought into accord with the new theory; as, though there is no whole value of n which gives exactly the values in their table, this is not important; these values are only approximate. In view of recent work by Rubens and Michel the author is inclined to consider that Planck's equation comes very near to reality. H. N. A.

1868. *The Röntgen Spectral Terms.* **G. Wentzel.** (Zeits. f. Physik, 16. 1. pp. 46–53, 1923.)—In an earlier communication [see Abstract 1146 (1922)] Sommerfeld and the author have shown that the regularities in the terms of the Röntgen spectrum can be described in an especially simple and comprehensive way if use be made of the numerical expression of the term magnitudes of the relativity term formula given by Sommerfeld. This knowledge of the term dimensions has been considerably extended through the recent measurements by Coster of the L-series of the lighter elements, so that a fresh numerical investigation of the Röntgen spectral terms appeared opportune. The following empirical formula has been derived:

$$\nu/\mathrm{R} = \left[\frac{\mathrm{Z} - s(\mathrm{Z}, n+n')}{n+n'} - 0{,}58\,.\,\phi(m)\right]^2 + a^2\left(\frac{1}{4} + \frac{n'}{n}\right).\left[\frac{\mathrm{Z} - d(n+n', m)}{n+n'}\right]$$
$$+ a^4\left[\frac{1}{8} + \frac{3}{4}\frac{n'}{n} + \frac{3}{2}\left(\frac{n'}{n}\right)^2 + \frac{1}{4}\left(\frac{n'}{n}\right)^3\right].\left[\frac{\mathrm{Z} - d(n+n', m}{n+n'}\right]^6 + \ldots$$

Z is the atomic number, n, n', and m are the quantum numbers, and d is a number independent of Z which has an individual empirical value to be determined for every term. The terms with

$$a^2, a^4 \ldots [a^2 = 5{,}315\,.\,10^{-5}]$$

denote the regular or relativistic and the term $-0{,}58\,.\,\phi(m)$ the irregular structures respectively. The paper is replete with tables of data. H. H. Ho.

1869. *X-Ray Determination of the Structure of Metal Foil.* **H. Mark** and **K. Weissenberg.** (Zeits. f. Physik, 14. 5. pp. 328–341, 1923.)—Polyáni has showed that, when deformation of a metal wire made up of numerous small crystals takes place, deformations of the individual crystal grains are produced, so that the problem of alteration of properties in the wire reduces itself to a determination of the mechanism of the action in the grains. Experiments with "unit crystals" of zinc, which are about 1000 times as large as the crystal grains in ordinary zinc, have shown that in consequence of the space-lattice structure the distortion does not take place in the direction of the force, but that a gliding action occurs along certain crystallographic planes, and that gliding layers are formed, which slide in a particular direction and then bend round into the direction of the force. It seems probable that something similar to this takes place in the crystal grains of ordinary metal wires when they are permanently stretched. Deformation by rolling should also bring the gliding directions into the direction of the force, and the gliding planes should be parallel to the plane of the resultant sheet or foil. A series of face-centred metals, Ag, Au, Pt, Cu, Al, have been examined by Debye and Scherrer's X-ray method. It was found that the rings, which are observed with a number of small crystals arranged irregularly, showed darker spots on the circumference. These were ascribed to a more or less regular arrangement of the crystals in the plane of the foil, with relation to the direction in which it had been rolled. The theory is worked out in detail, and carefully tested by taking X-ray photographs with different inclinations of the foil, and with suitable X-ray wave-lengths. In silver foil $[11\bar{2}]$ is parallel to the direction of rolling, with a scattering of about 8°; $[111]$ is at right angles to this, as are also directions which lie in the $[11\bar{2}]$ plane, and make an angle $\epsilon \leqq 35°$ with $[111]$:—$[1\bar{1}0]$ and directions which lie in the $[112]$ plane, and make an angle $\epsilon \leqq 35°$ with $[1\bar{1}0]$, are parallel to the normal to the surface. There is also some indication of a second group of space lattices. These are more marked in Au and Pt. The metals Cu, Pt, Al, and Au show the same space-lattice structure as Ag, but with different scattering.

H. N. A.

1870. *Genuine Optic Resonance with Röntgen Rays.* **G. Mie.** (Zeits. f. Physik, 15. 1. pp. 56–57, 1923.)—Experiments are described in which true resonance, as distinguished from fluorescence, was obtained with Röntgen rays. If the atoms of a crystal resonate to definite waves they must reflect them selectively, because they vibrate coherently. The characteristic mark of genuine resonance is that between exciting waves and resonator vibration a regular phase-difference exists. Fluorescence radiation on the contrary is not regularly reflected. Thus resonance and fluorescence may be experimentally distinguished. The author allowed Röntgen radiation to be reflected from a rotating crystal and the spectrum received on a cylindrical curved film. Selective reflection was observed with zinc-blende, galena, and bismuth. The places of selective reflected radiation were distinguished from those of fluorescence radiation in that they formed wider bands but no sharp lines. The widening seems due not to imperfect interference of a monochromatic kind of rays but to reflection of a wider extent of waves indicating a not quite sharp resonance.

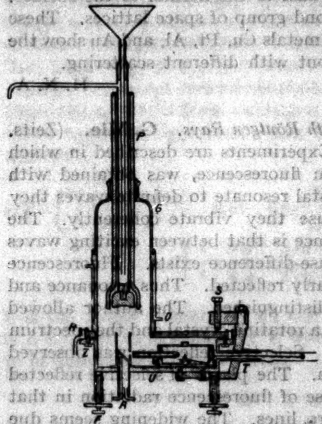
J. J. S.

1871. *X-Ray Isochromats of Molybdenum.* **D. L. Webster** and **A. E. Hennings.** (Phys. Rev. 21. pp. 312–325, March, 1923.)—In the ordinary X-ray spectrum intensity as a function of wave-length cannot be interpreted in terms of energy because of the unknown variation of several factors with frequency. The case of isochromats,* intensity per kathode ray for a given wave-length as a function of voltage, is a simpler problem. The authors have made measurements up to twice the quantum voltage in each case (up to 70 kv.) and both voltage and current determined to 0·1 %. The correction for crystal scattering was determined from measurements on each side of the reflected beam—this correction was less than 1 % except near the quantum voltage. The correction for target absorption was computed from data given in previous paper [see Abstract 1880 (1923)]. After making these corrections the isochromats were found to be straight lines. The results for 0·41 and 1·23 Å agree within 1 or 2 % with an empirical equation for isochromats given in the paper. A. B. W.

---

* An isochromat is a graph of intensity against potential for a single frequency

1872. *A New X-Ray Apparatus with High-Vacuum Camera.* **A. Schleede and H. Gantzckow.** (Zeits. f. Physik, 15. 2 and 3. pp. 184–188, 1923.)—In previous spectrometric investigations it has been customary to excite long wave-lengths in a high-vacuum tube and to pass the radiations into a camera, *via* a window of some suitable material. The material most both allow a high-vacuum to be obtained and allow the passage of the radiation without absorption. To overcome this difficulty the authors have constructed an instrument in which the camera is itself within the vacuum. The spectroscopic method used is that of Debye and Scherrer, but the principle is applicable to other methods. The apparatus (see diagram) consists of an upper part O and lower part U, jointed above the centering screws Z, and the vacuum-proof connection is made by a rubber-mercury connection which necessitates the upper and lower parts being pressed together by four pressure screws S. The mercury for this seal can be supplied or withdrawn by the glass level in the rim R. The lower part is best turned in one piece, is carried by four screws F, and within it is a water-cooled antikathode A and a tube T which serves for connection to the vacuum pump. To diminish secondary electron action as far as possible the antikathode is surrounded by an aluminium sleeve. The upper part can be air-cooled and carries an insulated kathode. This insulation is a difficulty when the tube is gas-filled, as quartz and glass are unsuitable owing to their breakdown at high voltages. The best material is porcelain, as thick as possible. The porcelain tube P is inserted *via* a cemented conical fibre ring. The moderately heated kathode can be cooled by dropping water. Metallic parts are all of brass. In the lower part the camera can be placed. This is also brass and the difficulty is to centre accurately the crystal container, the method being described. The crystal container may be slowly rotated, *via* T, by clockwork. Resulting photographs with and without rotation are shown, but whereas rotation gives increased definition, still greater definition is obtained when the crystal is more finely ground in a mortar. To produce the vacuum first an oil pump is used, and later, at lower pressures, a quartz-mercury pump. The gas and photographic



film is dried by phosphorus pentoxide. A special valve to regulate the pressure is illustrated. The dimensions of the complete apparatus are given in detail. The apparatus is designed for work with long wavelengths to investigate the structure of organic compounds. B. J. L.

1873. ***Measurements of the X-Ray Spectrum.*** **E. Hjalmar.** (Zeits. f. Physik, 15. 2 and 3. pp. 65–109, 1923.)—If n is Bohr's total quantum number, which designates the electron shell, 1 for K, 2 for L, and so on, and k is his azimuthal quantum number, then the K shell has one level $n = 0$, $k = 1$; the L shell has three levels, $n = 1$, $k = 1, 1, 2$; the M shell five levels, $n = 2$, $k = 1, 1, 2, 2, 3$; the N shell seven levels; the O shell five, and the P shell three. Certain of these levels, as shown in a diagram in the paper, are a and the rest b levels, and the combination principle states that all passages from one level to another must be from a to b, or from b to a, and the values of k for the two levels must be equal or differ by one. This cuts down the number of possible L lines from 21 to 7, six of which have been observed by Coster. The author has investigated the M lines of 16 elements from U to Dy, and less thoroughly their N, O, and P lines; a gypsum plate was employed in a Siegbahn spectrograph, though sugar and calc-spar were also used. Ten out of the possible lines due to a fall from the N to the M levels were observed with some of these elements, the heavier elements showing the greater number of lines. The α_1, β and γ lines were well defined on both sides; this is contrary to Stenström's observations, and may be due to the use of a better gypsum crystal. On the "hard" side of these lines was a band, which was resolved into lines α', α'', β', β'', γ', and γ''; β''' was observed with uranium. Some of these satellites have been previously observed by Stenstroöm; the author devotes some attention to the theory of these lines. Lines due to fall from O to M levels and from outer levels to the N levels have always a difference of one between the two k's. This agrees with the fact that when, for other levels, the two k's are equal, the lines are always weak. The variations from Bragg's relation between wave-length and deflection in the different orders of the spectrum were experimentally investigated, and Ewald's reflexion theory was found to give the only possible explanation of the facts. The values of V/R were determined for several N, O, and P levels and agree well with those given by Bohr and Coster. H. N. A.

1874. ***X-Ray Measurements.*** (Phys. Soc., Proc. 35. pp. 41D–45D; Disc., 45D, June, 1923.)—Descriptions are given of an apparatus suitable for X-ray measurements, including Solomon's ionometer and a spectrometer for measuring end radiation, due to Staunig, March, and Fritz. W. R. C.

1875. *Characteristic L Absorption of X-Rays for Elements of Atomic Numbers* 62 *to* 77. **J. M. Cork.** (Phys. Rev. 21. pp. 326–333, March, 1923.)—The three L absorption bands for elements of atomic numbers 55 to 60 have been determined by Hertz [Abstract 1090 (1921)], and for elements of atomic numbers 74 and 78 to 92 by de Broglie and Duane [Abstract 459 (1921)]. As these data are of importance in constructing theories of the inner atomic structure, alternate elements in the gap, atomic numbers 62 to 77 have been investigated by the author. The regular doublet differences $\Delta(\nu/N) = (\nu_{L_2} - \nu_{L_1})/N = L_2 - L_1$ are found to agree well with values calculated from the Sommerfeld formula. For the range of elements mentioned in this paper the empirical expression $\Delta(\nu/N) = Kz^5$ is found to hold within the experimental limits where K has the following values $4 \cdot 44 \times 10^{-8}$ for $L_2 - L_1$, $1 \cdot 97 \times 10^{-9}$ for $M_2 - M_1$ and $9 \cdot 60 \times 10^{-7}$ for $M_4 - M_3$.

A modified notation is proposed for X-ray emission lines.

A. B. W.

1876. *Diffraction of X-Rays in Liquids. Part II.* **W. H. Keesom and J. de Smedt.** (K. Akad. Amsterdam, Proc. 26. 1 and 2. pp. 112–115, 1923. In English.)—The experiments on the diffraction of X-rays described in Part I of this paper [see Abstract 2094 (1922)] were all made with Kα-rays (λ = 1·54 Å.) of copper. For certain reasons it was desirable to repeat some of the experiments with rays of shorter wave-length, *viz.* the Kα-rays of molybdenum (λ = 0·71 Å.). The method and apparatus were the same as previously employed. The liquids used were liquid oxygen, neon, and nitrogen, also water and CS_2.

For oxygen, argon, water, and nitrogen it has been confirmed that the principal ring is due to neighbouring molecules, which may be considered to be distributed approximately as spheres packed together as closely as possible and filling up the space occupied by the liquid. The results are tabulated below:

Substance.	ϕ (λ = 0·71 Å.).	*a*.	$1 \cdot 33\sqrt[3]{\frac{M}{d}}$
Oxygen (9 plates) ..	12·50°	4·0 Å.	4·0 Å.
Argon (1 plate) ..	13·0	3·85	4·1
Water (1 plate) ..	13·44	3·73	3·6
Nitrogen (1 plate) ..	11·34	4·42	4·4
CS_2 (1 plate) ..	13·23	3·8	5·2

In the above table ϕ is the half-angle of the cone formed by the diffracted X-rays; M and *d* are molecular weight and density, whilst $a = \dfrac{7 \cdot 72\,\lambda}{4\pi \sin \frac{\phi}{2}}$ is the distance between the diffracting particles. The anomalous behaviour of CS_2 is being investigated. On six plates of oxygen and on those of argon and nitrogen the second ring is distinctly measurable.

	ϕ.	*a*.
Oxygen	19·5°	2·57 Å.
Argon	18·9	2·65
Nitrogen	17·0	2·95

These values of *a* show a striking agreement with the values previously obtained [see Abstract 890 (1921)] for the diameter of the molecules, *viz.* for oxygen σ = 2·65 Å., for nitrogen σ = 2·98 Å. Slight evidence has also been obtained of a third ring in the case of oxygen and of argon, but this is not considered conclusive.

A. B. W.

1877. *X-Ray Scattering and J-Radiations.* **C. G. Barkla** and **R. R. C. Sale.** (Phil. Mag. 45. pp. 737–750, April, 1923.)—Further experiments on the scattering of X-rays show that even the light elements hydrogen, carbon, and oxygen (together) show a very slight increase of scattering with wave-length. Over a considerable range, however, the outstanding feature is the constancy of the scattering coefficient—as compared with absorption and other coefficients.

In aluminium and more markedly in copper, the scattering increases more rapidly with wave-length. The relative intensities of scattering by hydrogen, carbon, and oxygen (on paper), aluminium, and copper have been obtained by another method, and the results for the last two—the others have not been previously determined—agree very closely with those given by Barkla and J. G. Dunlop [see Abstract 685 (1916)]. Over a considerable range of wave-lengths no difference between the absorption coefficient of the primary radiation and of the secondary X-radiation (scattered) from paper has been detected. The investigations described have not furnished the evidence of the existence of J characteristic radiation which so many results led the authors to expect. A further communication on this subject is promised. A. B. W.

1878. *Scattering of X-Rays and the Quantum Theory.* **P. Debye.** (Phys. Zeits. 24. pp. 161–166, April 15, 1923.)—The scattering of X-rays shows a known polarisation and unequal distribution of intensity in different directions in space. The radiation proceeding from a free electron is calculated according to the laws of electrodynamics and the theoretical value so found, as J. J. Thomson has shown, is in qualitative accord with experiment. The present paper, which is of a theoretical nature, and mainly mathematical, deals with the problem of the scattering of the X-rays and the application to it of the quantum theory. A. E. G.

1879. *On the Reflection of X-Rays at the Surface of Substances.* **F. Wolfers.** (Comptes Rendus, 176. pp. 1385–1387, May 14, 1923.)—The above phenomenon has been discovered by the following experiment. A film of double layer or two simple films suitably superposed are rolled upon a wooden cylinder whose axis is normal to a large pencil of sensibly parallel X-rays. Those rays which traverse tangentially the layers of bromide are strongly absorbed and the internal layer projects upon the other a white ray. The dark areas on either side of this ray are very different. The author has now investigated these dark contours on radiographs in detail, and his preliminary experiments have shown that the apparent contour of any object sufficiently dense as projected by X-rays upon a plate a short distance away is bordered by a black band observable in the microscope and sufficiently sharply defined for measurements. This is opined to be a probable reflection of the rays, because it cannot be ascribed to an ordinary secondary emission, a number of experiments to this end having failed, *e.g.* the interposition of screens does not sensibly modify the breadth of the black band which must therefore be due to rays sensibly analogous to the incident rays. Reasons are given for excluding diffusion, fluorescence, etc., as the cause of the phenomenon, which appears to conform with the following laws: (1) The plates utilised, the period of exposure, and the interposed medium, are without appreciable effect. (2) The pencil assumed to be reflected is the more intense as the reflecting surface is formed of heavier atoms, *e.g.* it is very intense with all the common metals and mercury, appreciable with aluminium, and nil with wood, celluloid, etc. (3) The breadth of the pencil, defining the maximum angle of the rays with the surface, is independent of the radius of curvature and degree of polish. (4) This angle depends very little or not at all on the nature of the reflector. (5) It is exactly proportional to the distance of the sensible layer at the line of contact of the tangent ray if this distance does not exceed about 2 cm. (6) The maximum angle decreases regularly with the length of the wave. (7) The tint of the band is not uniform, being darker in the part remote from the contour. The author, however, is aware of the insufficiency of his reflection hypothesis and promises further experiments. H. H. Ho.

1880. *Penetration of Kathode Rays in Molybdenum.* **D. L. Webster and A. E. Hennings.** (Phys. Rev. 21. pp. 301–311, March, 1923.)—The further a kathode ray penetrates into the target the more the X-rays excited by it are absorbed by the target material before coming out. X-rays just harder than the K-absorption limit are absorbed more strongly than those just softer. If the intensity of the spectrum emitted, except for the characteristics, is a continuous function of the wave-length and if the discontinuity in absorption coefficient is μ_k and the observed ratio of intensities on each side of the discontinuity is R, then the logarithmic mean depth of penetration $\bar{x} = \mu k^{-1} \log R^{-1}$, for voltages above the minimum necessary to excite radiation of the absorption limit frequency, 20 kv. in the case of Mo. To reduce the effect of stray X-rays a calcite crystal was used and narrow slits which limited the incident beam to 8½°. The voltages required to make the mean depth of excitation of this frequency equal to 1, 2, and 3 μ were found to be 24, 44, and 67 kv. app. respectively. The increased difficulty of penetration beyond the first micron is probably due to the deflection of the kathode rays by the atoms. The importance of these observations in theoretical problems is discussed. A. B. W.

RADIO-ACTIVITY.

1881. *Radio-Activity of some Solid Products of Etna.* **G. Trovato.** (N. Cimento, 25. pp. 177–189, March–April, 1923).—From the examination of a large number of samples the author concludes that the volcanic products of Etna all present slight radio-activity. He places them in the following order of increasing activity: Lava recently erupted, compact lava, scoria, gravel, old lava, basalt, cinders, mud of thermal water, tufa, vegetable loam. The vegetable loam, tufa, and cinders emit an emanation of the same nature as that of thorium. The radio-activity of all the products is feeble. The vegetable loams are in general the most active of the products and recently erupted lava the least. The most active loam observed up to the present behaves as if it contains about four centigrams of the hydrate of thorium per kilogram; the mud as if it contains about 1½ centigrams, the cinders and more active lava as if they contain about two milligrams per kilogram of substance. It would appear from this that the radio-activity of volcanic products diminishes with increase of depth, a result which is in accord with that found by Bellia for gaseous products. A. E. G.

1882. *Atomic Projectiles and their Properties.* **E. Rutherford.** (Engineering, 115. pp. 242–243, Feb. 23; 264–266, March 2; 306–308, March 9; 338–340, March 16; 358–359, March 23, and pp. 798–800, June 29, 1923. Electrician, 91. pp. 60–61, July 20; 120–121, Aug. 3, and pp. 144–145, Aug. 10, 1923. A series of six papers delivered at the Royal Inst.)—In this course of lectures an account is given of the properties of swiftly-moving electrons and atoms, and of the effects produced by them in passing through matter. Such a study had played a very important part in modern development of physics, having added materially to our knowledge of atomic structure. This was due to the fact that these swiftly-moving particles afforded the best means of penetrating into the interior of an atom, and of searching out its inner structure and disclosing the magnitude and distribution of the forces which held the atom in equilibrium.

In the first lecture comparisons were made of the magnitude of the velocities which could be impressed on ordinary matter by various means, both terrestrial and astronomical. Consideration was also given to the effects of impacts at various speeds. It was shown that the highest controllable speeds which were generated on the earth were obtained in vacuum tubes in which electrons were accelerated by electric fields. Thus speeds as high as 58,000 km. per second were attained by electrons falling through 10,000 volts; whilst positive rays of hydrogen under this voltage might acquire a velocity of 1400 km. per sec.

In the second lecture more detailed consideration was given to the properties of low-speed electrons, and an outline given of Townsend's theory of ionisation by collision, dealing with the case of spark potentials when both negative and positive ions were effective in ionising by collision. Thermionic and photoelectric phenomena were also dealt with in this connection; reference was made to the emission of radiation by impact of electrons and the converse case of emission of electrons on absorption of radiation.

The third lecture dealt mainly with the generation of spectral series, based on theories of electron orbits; the production of characteristic X-rays by impact of electrons on the elements (Moseley's work being quoted in this connection). An elementary account was also given of the properties of α-particles, pointing out that the α-particle had more energy than any electron yet known to us, and that its passage through a gas was marked by very intense ionisation, which could be demonstrated both by electrical methods and Wilson's condensation method. This subject was continued in the fourth lecture, where reference was made to condensation "trail" photographs showing the tracks of α-particles through gas and revealing "forked" or "branched" tracks, which indicate collision with gas atoms in the path of the α-particle. In this way the conception of the nucleus of the atom was introduced and the action of intense nuclear fields of force on the impinging α-particle were discussed. Measurements of "forked trails" showed that even in atomic cases such as these the ordinary laws of mechanics held, both energy and momentum were conserved.

In the fifth lecture, reference was made to the calculations of C. G. Darwin and the experiments of Chadwick and Bieler, which suggested that the α-particle might be a spheroid of the axes $a = 8 \times 10^{-13}$ cm. and $b = 4 \times 10^{-13}$ cm. The law of inverse squares held outside but not inside this spheroid.

The final lecture dealt with the application of the method to the attack of an atom. A detailed description was given of the effect of close collisions of α-particles with the nuclei of different elements, showing how high-speed hydrogen and oxygen nuclei, having ranges even greater than that of the α-particles themselves, were produced. By electrostatic and magnetic analysis of such high-speed particles it was definitely proved that high-speed hydrogen nuclei were produced by close collision of α-particles with atoms of nitrogen, aluminium, and other elements.

The bearing of these and similar observations was, in conclusion, discussed in relation to the problem of nuclear constitution of atoms of the elements. A. B. W.

1883. *The Present Situation in the Radium Industry. Discovery of Radium.* **H. E. Bishop.** (Science, 57. pp. 341–345, March 23, 1923. Paper read before joint meeting of the Am. Chem. Soc., the Am. Electrochem. Soc., and the Soc. Chim. Industrielle, New York, Feb., 1923.)

1884. *An Arrangement for the Measurement of Strong Ionisations due to α-Rays.* **I. Curie.** (Comptes Rendus, 176. pp. 1462–1464, May 22, 1923.)—When it is desired to measure the current due to the total ionisation produced by a source of α-rays, the difference of potential necessary for obtaining the saturation current increases with the intensity of the source and becomes very difficult to realise practically if the current exceeds certain values. The arrangement now described solves this difficulty. The principle of the method consists in utilising for the production of the ionisation current only a small portion of the path of the α-rays. Experimental details are given very fully. The apparatus is claimed to be particularly convenient for rapid measurements.
H. H. Ho.

1885. *Photography of Ionisation-Tracks of the Rest-Atoms of Radio-Active Elements.* **D. M. Bose** and **S. K. Ghosh.** (Phil. Mag. 45. pp. 1050–1054, May, 1923.)—When an atom of a radio-active substance disintegrates with the emission of an α-particle, the rest-atom recoils back in the opposite direction with the same momentum as that of the α-particle, producing intense ionisation along its path in a similar manner. The author now describes a modification of Wilson's expansion apparatus for photographing the tracks of these ionising recoil-atoms and a number of photographs are reproduced in the paper. A. B. W.

1886. *Life-History of an α-Particle.* **E. Rutherford.** (Engineering, 115. pp. 769–770, June 22, 1923. Paper read before the Roy. Inst. Electrician, 91. pp. 194–195, Aug. 24, 1923. Nature, 112. pp. 305–312, Aug. 25, 1923, Suppt.)—A brief summary of the most recent researches on the origin and emission of α-particles. The velocity, range, and ionising properties of these particles are dealt with in some detail as well as their deflection in electrostatic and magnetic fields. Recent experiments had shown that the α-particles were not all deflected as if they carried the two charges ascribed to them, the results showed that some of the particles picked up one and others two electrons, thereby becoming singly-charged or neutral. These effects became more noticeable after the α-particles had passed through thin foils of metal. It was demonstrated also that an α-particle after capture of an electron might lose it again, and measurements had been made of the mean free paths of the α-particle when capturing and losing electrons. The rapidity of capture was great compared with the rapidity of loss of electrons. Probability considerations showed, however, that the chance of an α-particle at high speed capturing an electron was very small. It became necessary to assume that at the instant an α-particle captures an electron energy is lost in radiation, by a kind of inverse photoelectric phenomenon. That being the case, some 3 % of the energy of the α-particle should go out in soft radiation. A. B. W.

1887. *Theory of δ-Radiation.* **P. L. Kapitza.** (Phil. Mag. 45. pp. 989–998. May, 1923.)—The general explanation of δ-radiation usually advanced is as follows. When an α-particle penetrates into a body, it loses its kinetic energy in ionising atoms of the body. The liberated electrons possess certain speeds, and after several collisions may escape from the surface. These escaped electrons form the δ-radiation. Such a general theory is, however, insufficient to form a quantitative basis. The author now considers the phenomenon from a statistical standpoint and obtains some numerical values for the speeds and numbers of electrons in the δ-radiation. The theory advanced is based on the assumption that the electron emission is thermionic. When an α-particle collides with atoms of the body local heating takes place and several thousand degrees' rise of temperature is shown to be possible. Such a process is shown to give values of speeds and numbers of electrons in accordance with experimental observations. A. B. W.

1888. *Relation of Actinium to Uranium.* **A. S. Russell.** (Nature, 111. pp. 703–704, May 26, 1923.)—The most probable origin of the actinium series is that Uranium II undergoes a dual change in which about 96 % of atoms from ionium, and the remainder from UrY, the product of which, proto-actinium, is the parent of the actinium series. An alternative view is that UrI undergoes the dual change. On the basis of recent experimental work, and from a survey of general relations in radioactivity, the author proposes the following scheme:

Element.	Period.	Atomic Number.	Radiation.	Atomic Weight.
Actino-Uranium I ..	$>5 \times 10^9$ years	92	α	240
Uranium Y_1	25·5 hours	90	β	236
Uranium Y_2	very short	91	β	236
Actino-Ur II	$>2 \times 10^6$ years	92	α	236
Parent of Proto-Act..	>20 years	90	β	232
Proto-Actinium	$<1{\cdot}2 \times 10^4$ years	91	α	232
Actinium	20 years	89	β	228
Radio-Actinium,etc. .	19·5 days	90	α	228

A. B. W.

HEAT.

1889. *An Intercomparison of the High-Temperature Scales in Use in this Country (U.S.A.) with those in Use in England.* **W. E. Forsythe.** (Frank. Inst., J. 195. pp. 857–858, June, 1923.)—A comparison of the high-temperature scales of the Nela Research Laboratory (N.R.L.), the Bureau of Standards (B. of S.), the Physical Laboratory of the University of Wisconsin, and the Research Laboratory of the General Electric Co. was made in 1917 [see Abstract 541 (1918)] on several tungsten filament lamps made at the N.R.L. Good agreement was obtained. This inter-comparison has now been extended to the National Physical Laboratory (N.P.L.) on the basis of $c_2 = 14{,}350\,\mu \times$ deg.; melting-point of Au = 1336° K., melting-point of Pd. = 1828° K. [see Abstract 1159 (1922)], and it is found that the high-temperature scales in England and the United States are in excellent agreement, as shown in the following table:

Lamp.	Current.	N.R.L. Apr., 1920.	N.P.L. Apr., 1922.	N.R.L. June, 1922.	B. of S. Jan., 1923.	N.R.L. Jan., 1923.
T—77—B	5·2	1410°K.	1405°K.	1406°K.	1401°K.	1401°K.
	6·7	1599	1597	1595	1596	1591
	8·5	1796	1794	1794	1792	1791
	11·7	2106	2106	2104	2105	2104
T—78—C	15·4	1825	1825	1826	1824	1828
	20·4	2262	2266	2266	2265	2269
	27·4	2746	2758	2753	2755	2755

T. B.

1890. *The Specific Heats of Air, Steam, and Carbon Dioxide.* **W. D. Womersley.** (Roy. Soc., Proc. 103. pp. 183–184, April 3, 1923.)—This is a reply to R. T. Glazebrook's criticism [Abstract 1651 (1922)] of a paper under the above title [see Abstract 1331 (1922)]. The author's action in increasing Holborn and Hennings' numerical results for the specific heat of CO_2 by about 7½ % is defended on the grounds that (1) their results for air and steam are correspondingly low; (2) they do not fit curves at lower temperatures by Swann; (3) the discrepancies were similarly dealt with by the British Association Committee in 1908. Other points in R. T. Glazebrook's criticism are also answered. T. B.

1891. *Theory of the Specific Heat of Liquids.* **F. A. Lindemann.** (Phil. Mag. 45. pp. 1119–1120, June, 1923.)—A summary of the theory of the specific heat of liquids put forward by Honda [Abstract 706 (1923)] is given, and it is shown that several of the assumptions made are unjustifiable. The rotation of atoms about their centres of gravity is impossible owing to the smallness of their moments of inertia; also the work done against cohesion by expansion on fusion is not negligible. If the theory be accepted the potential energy must become free on melting, which does not occur. The value obtained theoretically on these assumptions for the ratio of the specific heats of mercury-vapour is 1·33, while observation gives 1·67.

The theory accepted by the author is that the atoms in a solid form a space lattice, and that the thermal energy at constant volume is in the form of translational oscillations. The restoring force is elastic provided the displacement is small; hence, the mean potential energy is equal to the mean kinetic energy at low temperatures. At the melting-point some discontinuities in the atom collide or overlap. The restoring force between the atoms is less in the liquid than in the solid, so that the characteristic temperature is lower. The balance of the latent heat might be accounted for by a term $3R\int_0^{T_m}\left\{f(\phi_1/T) - f(\phi_2/T)\right\} dT$, where ϕ_1 and ϕ_2 are the two characteristic temperatures. A. W. L.

1892. *The Heat of Vaporisation and the Difference of the Specific Heats in the Saturation State for Neon.* **E. Mathias, C. A. Crommelin,** and **H. K. Onnes.** (Comptes Rendus, 176. pp. 939–940, April 3, 1923.)—In a former note [see Abstract 2104 (1922)], the latent heats of vaporisation, (L), and the difference of the specific heats of the saturated vapour and of the liquid, $(m' - m)$, for argon, oxygen, nitrogen, and hydrogen, were given. The same quantities are now given for neon. L is calculated from the Clapeyron-Clausius equation, $L = (T/J)(1/\delta' - 1/\delta)(dp/dT)$, where p, the vapour tension, and δ, δ', the densities of the liquid and of the saturated vapour, are obtained from results of experiments in the Leyden cryogenic laboratory. The value of $m' - m$ is then obtained from the classical formula $m' - m = dL/dT - L/T$. Its value is found to be strongly negative up to the critical point, remaining negative at all temperatures, but passing through a maximum for a reduced temperature in the neighbourhood of 0·74. Neon being monatomic, it can be affirmed, as demonstrated by H. K. Onnes, that the specific heat of its saturated vapour is always negative. Tables are given containing values of ML, the molecular heat of vaporisation, and of $L\Delta/p_c$, the reduced heat of vaporisation for O_2, A, N_2, Ne, and H_2. (Δ is the critical density, and p_c the critical pressure at the same reduced temperature, $T/T_c = 0{\cdot}6$.) As is the case with the other thermal properties of these bodies, it is found that for the latent heats of vaporisation also, the deviations from the law of corresponding states is accentuated, in general, as their critical temperatures become lower. T. B.

1893. *Variations of Thermal Capacity in a Magnetic Field.* **B. Nannei.** (N. Cimento, 25. pp. 131–158, March–April, 1923.)—The thermal capacity of iron increases with increasing field until the field becomes 100 Gauss, and thereafter falls off steadily, being equal to that of demagnetised iron at about 300 Gauss. Iron once magnetised does not show the first part of the curve, but gives a continuous fall, until it has been re-heated. The thermal capacity of copper is not affected by a magnetic field; that of bismuth falls continuously with increasing field. A. D.

1894. *Evaporation Characteristics of Tungsten.* **G. R. Fonda.** (Phys. Rev. 21. pp. 343–347, March, 1923.)—Langmuir's method was used to study the rate of evaporation of tungsten filaments in vacuum as compared with that in the gases nitrogen and argon, and also to find how the evaporation depends on the crystalline structure of the wire. Drawn wire was used in all cases, both as "thoriated" and as "non-sag." The former contains 0·6–0·8 % of thoria, and is uniformly and invariably fine grain. The "non-sag" wire contains less than 0·1 % of impurities.

In crystallisation it varies from a structure as fine-grained as the thoriated tungsten to one characterised by excessively large and long crystals. It was found that in vacuum the rate of evaporation per cm.^{2} m is independent of the diameter a, from 1/20 to 1/4 mm., but is over 40 % greater for fine-grained than for very coarse-grained wires, probably because the evaporation at the boundaries of the crystals is abnormal. In *nitrogen* the rate varied from 2 to 5 % of that for the same wire in vacuum, and in *argon* from 1·3 to 3 %, increasing as the diameter decreased from 1/4 to 1/15 mm. The variation with size when gas was present is in agreement with the Langmuir theory of heat conduction for hot filaments, which supposes that there is around the wire a stationary film of gas through which the evaporated atoms must diffuse. The diameter b of the outer surface of this film varies with a according to the equation $b \log (b/a) = 0\cdot 86$, which leads to the equation $ma \log (b/a) = \text{const.}$, with which the experimental results agree. The constants for nitrogen and argon are inversely proportional to the molecular weights. A. W.

1895. *The Reaction Consequent upon the Evaporation of a Liquid and upon the Emission of Vapours from Small Orifices.* **W. G. Duffield.** (Phil. Mag. 45. pp. 641–688, April, 1923.)—The original problem was to discover whether in the process of evaporation or boiling there was any measurable mechanical reaction upon the surface from which the molecules were issuing. In an actual experiment, where molecules of vapour were escaping at the rate of ·03 gm. per second and at a speed of the order associated with a gas molecule (roughly 7×10^4 cm. per sec.) the surface should be losing momentum at the rate of $0\cdot 03 \times 7 \times 10^4$ dynes per sec., which is equal to the weight of 2·14 gms. The amount of reaction was tested by boiling a liquid, or allowing it to evaporate from the pan of a balance, and observing the rate at which the pointer moved. In none of the experiments was any reaction upon the surface observed. Further experiments were carried out on the efflux of steam from a small aperture in the side of a boiler. By using a large boiling surface and a small aperture the number of molecules driven out in each second per unit area could be enormously increased. A form of Hero's engine was employed, consisting of a boiler suspended by a torsion fibre, and so arranged that the issue of steam twisted this through an angle which could be measured. The apertures at the ends of the arms were circular holes in thin brass sheet; their size and number could be varied. For large apertures it was not found possible to obtain a rate of discharge which would give any measurable recoil, although a calculation similar to that given above indicated that a twist of 30,000 degrees should have occurred. It was only when an orifice was employed which was very small compared with the area of the boiling surface, in other words, when D/A, the discharge of vapour per unit area, became large, that measurable amounts of recoil were obtained. In order to explain these and similar results, it is assumed that there is some compensating reaction between the projected molecules, and the molecules of air or vapour in the space above the liquid, which prevents the loss of momentum of the projected material from becoming evident as a pressure upon the surface. The liquid is being bombarded by molecules of air or vapour whose impacts occasion the usual gas pressure, but as the rate of evaporation increases, some or all of these encounter the molecules projected from the liquid, and are prevented from communicating their full momentum to the surface. It was found that the limiting rate of discharge without reaction occurs when twice as many molecules leave the surface as would have struck it from above had there been no evaporation. This limiting rate can easily be found to be about 15 gms. per second per sq. cm. Mathematical investigation with certain assumptions shows that the total reaction R upon a vessel from which steam is issuing at the rate of D gms. per second from an aperture of area A is given by $R = Dv_l - \pi A + \frac{1}{2}(\pi A(r + 1)e^{-\mu(r+1)D/A}$, π being the external pressure, r the ratio of the velocity (v_l) of discharge normally, to the velocity with which an external molecule strikes the surface. The actual value of the constant μ is not obtainable from theoretical considerations, but is evaluated from a single series of observations, and its applicability tested to other series. The observed reactions for steam issuing from an orifice under pressures varying from 1/4000 to 1/3 of an atmosphere, the reactions ranging from 6 dynes to over 10^6 dynes showed good agreement with the equation. The same equation also fitted very closely some results given by Rosenhain in Proc. Inst. C.E. [Abstract 2078 (1900)] for high rates of discharge of steam from a nozzle at high boiler pressures. For these results the equation is simplified to $R = Dv_l - \pi A$, for D becomes so large that the factor $e^{-\mu(r+1)D/A}$ becomes negligible, which means that all the external momentum is absorbed before it reaches the aperture. It is found that curves drawn to coordinate D/A with R all meet the axis of D/A at the same point. This point corresponds with a rate of discharge of about 15 gms. per sq. cm. per second, which means that below this rate of discharge there is no reaction on the nozzle. Other similar cases involving the discharge of a vapour from a liquid, *e.g* the case of a saturated vapour above the mercury in a barometer tube are also considered. T. B.

1896. *On the Number of Impacts between Several Molecules.* **J. K. Syckin.** (Phys. Zeits. 24. pp. 236–239, June 1, 1923.)—This paper, which is entirely mathematical, derives an expression for the number of impacts in unit time of n_1 molecules of one kind with n_2 molecules of a second kind within a sphere of volume σ (very small and comparable with the molecular dimensions) and radius r. N_1 and N_2 are the numbers of the respective molecules of molecular weights M_1 and M_2 in unit volume. T is the temperature, and R the gas constant. The general formula deduced is :

$$V = \frac{N_1^{n_1} N_2^{n_2} \sigma^{n-1}}{\underline{|n_1}\ \underline{|n_2} \cdot r} \sqrt{0 \cdot 8\pi RT} \sqrt{\frac{\frac{n_1}{M_1} + \frac{n_2}{M_2}}{n_1 + n_2}}$$

By the necessary simplification the Boltzmann formula for the special case of the impact of two molecules is shown to be obtained. This formula is claimed to be applicable in the kinetics of chemical processes of any order. H. H. Ho.

1897. *Fused Salts. Part II.* **W. Herz.** (Zeits. Elektrochem. 29. pp. 274–276, June 1, 1923.)—Walden having calculated the internal pressures B of liquids by Stefan's formula $B = L/2v$, where L is the heat of evaporation per gramme and v the specific volume, the author applies the formula to solutions which chemically differ from ordinary solutions, that is, to fusions of the alkali halides. Taking the data of Ruff, Wartenberg, and Jaeger, he further calculates, with the aid of the surface tension at the boiling-point, the molecular diameters by means of Ostwald's formula. He finds that the product of thermal dilatation and of boiling-point in K° is fairly constant. The internal pressures deduced are high: 59,800 atmos. for LiF, 21,500 atmos. for LiCl, 23,000 for KF, 7600 atmos. for RbI; as regards the molecular diameters, there is no definite rise or fall with the atomic weight. The author admits that his former critical pressures [Abstract 518 (1923)] were much too high, probably because salt fusions must not be regarded as non-associated liquids. H. B.

1898. *Pressure of Gaseous Mixtures.* **I. Masson** and **L. G. F. Dolley.** (Roy. Soc., Proc. 103. pp. 524–538, June 1, 1923.)—Dalton's law of partial pressures may be stated in two ways, which may be termed, (*a*) the law of additive pressures; (*b*) the law of additive volumes. Of these, (*a*) may be stated thus: The total pressure of a gaseous mixture is the sum of the pressures which can be experimentally measured by enclosing each constituent gas in turn by itself in the volume of the mixture. The law of additive volumes, (*b*), is that the volume of a mixture is the sum of the volumes of the separate components, all measured at a fixed pressure. Binary mixtures of two of the gases, ethylene, argon, and oxygen, have been employed up to 125 atmospheres pressure in order to test Dalton's law in its two forms. It is found that in general neither form of the law represents the true state of matters, the law of additive volumes being the more inaccurate. The law of additive pressures, again, fails because it neglects the fact that the space in which each gas is enclosed is already partly filled up by the molecules of the other, and because it makes no allowance for mutual attractions between the molecules of the two gases. As an example of additive volumes, it is found in the case of an equi-molecular mixture of argon and ethylene that the volume of the mixture at 80 atmospheres is greater than the additive volume at 80 atmospheres by 24 per cent. Tables and curves are given showing percentage deviations from the law of additive volumes for pressures from 30 to 125 atmospheres and for various percentages of each gas. The curves show (for argon-ethylene) that the volume of the mixture is always *greater* than that of the constituents, except for pressures over 110 atmospheres. The maximum change in volume occurs at pressures of about 75 atmospheres, where it reaches 31·5 per cent. In the measurements on additive pressures, the pressures of the mixtures are usually *less* than the additive pressures, except in the case of the argon-ethylene mixture at pressures over 80 atmospheres. The argon-oxygen mixtures show the least changes both in volume and in pressure. The development from the standpoint of equations of state of some of the facts recorded is promised in a future communication. T. B.

1899. *The "Loop" of J. Thomson and the New Equation of State of a Gas.* **A. Leduc.** (Comptes Rendus, 176. pp. 1456–1458, May 22, 1923.)—Referring to the new equation of state submitted to the Académie des Sciences [Abstract 1428 1923], the author shows how the "loop" which it describes between the extremities of the line of liquefaction satisfies the classical condition: The calculation has been made on the 20° isothermal of carbonic acid after Amagat. It is known that the isothermal cycle included by the "loop" and the line of liquefaction must have a "null" area. That is, if v_1 and v_2 are the specific volumes of the fluid at the extremities of the liquefaction line, and F is the pressure of saturation, then $F(v_2 - v_1) = \int_{v_1}^{v_2} p \, . \, dv$, p being the ordinate of a point on the loop. An equation of a previous note (equation 9) enables the value of the integral above to be obtained. From Amagat's results for CO_2 at 20°, $F = 56 \cdot 3$ atm., $\nu_1 = 1 \cdot 303$ c.c., $\nu_2 = 5 \cdot 265$ c.c. Hence $F(\nu_2 - \nu_1) = 2 \cdot 260 \times 10^8$ c.g.s. Also $\int_{\nu_1}^{\nu_2} p \, . \, dv = 2 \cdot 245 \times 10^8$ c.g.s., an agreement within one part in 150. If the Clausius equation $p = r\mathrm{T}/(\nu - a) - b/[\mathrm{T}(\nu + c)^2]$ be similarly treated, it is found that $\int_{\nu_1}^{\nu_2} p \, . \, dv$ along the loop $= 2 \cdot 293 \times 10^8$ c.g.s. The difference between this value and $F(\nu_2 - \nu_1)$ being here one part in 69, or more than double that given by the author's equation. With van der Waals' equation the discrepancy is still greater. T. B.

1900. *Adiabatic Invariants of Mechanical Systems.* **E. Fermi.** (N. Cimento, 25. pp. 171–175, March–April, 1923.)—Burgers [Abstract 284 (1918)] has shown that the quantities $I_k = \oint p_k dq_k$ can be regarded as adiabatic invariants for any system if the variables are separable at any instant. The author shows that this does not follow unless they are further separable at every instant and gives a simple diagram to demonstrate this. A. Wh.

1901. *Deduction of Stefan's Law.* **Auric.** (Comptes Rendus, 176. p. 1455, May 22, 1923.)—Consider an atomic nucleus of mass M around which circulate n electrons of mass m in an elliptic orbit of major axis $2a$. It is known that the mean kinetic energy U of the electron is $\mu Mm/2a$. On the kinetic theory the absolute temperature $T = \alpha U$ where $\alpha = 4 \cdot 86 \times 10^{-15}$. Hence $2a = \mu Mm\alpha/T$. The maximum volume occupied by the nucleus and its electrons is $(4\pi/3) \times (2a)^3 = (4\pi/3) \times (\mu Mm\alpha/T)^3$. The number of atomic nuclei in the unit of volume is the inverse of the volume above, *i.e.* $(3/4\pi) \times (T/\mu Mm\alpha)^3$. Each nucleus has an external energy of radiation equal to nT, hence the total energy of radiation is proportional to $[3n/4\pi(\mu Mm\alpha)^3] \times T_4 = \sigma T^4$, which is the well-known law of Stefan. T. B.

1902. *Total Radiation of Iron at High Temperatures.* **R. Hase.** (Zeits. f. Physik, 15. 1. pp. 54–55, 1923.)—The total radiation of iron was compared with that of a black body by means of a **V**-shaped folded plate 0·5 mm. thick and 30 × 10 cm. in surface heated electrically to temperatures from 750 to 1200° C. The temperature of the plate was measured by a platinum-platinum-rhodium thermo-element with its junction in the fold of the plate and the total emission by a radiation thermo-element. A curve is given showing the energy of radiation of the two bodies at various temperatures up to 1200°. At high temperatures the radiation of the iron gets nearer and nearer to that of the black body. The relation given by Hagen and Rubens from their experiments and by Planck theoretically between the reflecting power R of a metal and its specific resistance, *viz.*:

$$S = \frac{100 - R}{100} = \frac{0 \cdot 365}{\sqrt{\lambda}} \, . \, \sqrt{w},$$

where S = the total emission and w the specific resistance, is in agreement with the record of the observations made. J. J. S.

SOUND.

1903. *Speed of Sound in Liquids in Cylinders with Slightly Elastic Walls.* **H. G. Green.** (Phil. Mag. 45. pp. 907–918, May, 1923.)—By experimenting in 1847, Wertheim found that the speed of sound in an organ-pipe completely immersed in water was reduced to 1173 metres per second, and he put forward the theory that the water in the pipe behaved as a quasi-elastic solid. Helmholtz (1848), by a general discussion, showed that this theory could not be correct, and suggested that the effect was due to yielding of the pipe-walls, an interpretation supported by Kundt and Lehmann (1874) and by Dvořák in their experiments with water by the method of Kundt's dust tube. The author of the present paper here obtains mathematically an approximate expression for the speed on the hypothesis that the change (from normal value) is entirely due to the yield of the walls. On application of this expression to various experimental results, it is found that the deduced effect shows agreement which is, on the whole, sufficiently close to confirm Helmholtz's theory and also to neutralise the agreements which led to an apparent support of Wertheim's views. It is not, however, claimed to be sufficiently close to enable calculation to replace experiment wherever considerable accuracy is required, as it might be, for example, in very long pipe-lines for the transmission of power by water waves (G. Constantinesco's method).

E. H. B.

1904. *Acoustics of Rooms.* **E. A. Eckhardt.** (Frank. Inst., J. 195. pp. 799–814, June, 1923.)—The most important difficulty encountered in public assembly rooms is that of reverberation. Because of reverberation the sound heard at any moment by the audience is due to a number of consecutive syllables, instead of that due to a single syllable uttered by the speaker as is desirable. If somewhere in a closed room we begin to emit sound at a constant rate, the nearest surface will be the first to reflect, and more distant ones will reflect later, the time lag involved being greater the larger the room. For every quantity of sound energy incident on the walls a definite fraction is absorbed, this fraction depending on the nature of the surface. With advancing time the quantity of sound energy falling on the surfaces of the room increases till the rate of absorption equals the rate of emission by the source. The average sound intensity in the room has then its maximum value, which will be maintained while the sound emission continues unchanged. If now the sound emission is stopped, the sound intensity will gradually diminish until all the energy has been absorbed by the surfaces of the room. The formulæ for the growth and decay of the sound were developed by G. Jaeger [Abstract 54 (1912)], and are of the type of the growth and decay of an electric current in an inductive circuit. The paper includes a number of graphs showing the growth and decay of sounds heard from the successive utterances of syllables, and their overlapping or distinctness according to the constants for the room in question. It is pointed out that with increasing size of rooms the absorption per unit area of its surfaces must be increased in order that equally satisfactory acoustical results may be retained.

The quantitative relation is aS/V should be constant, where a is the mean coefficient of absorption of the surfaces of area S of the room of volume V. E. H. B.

1905. *Absolute Measurements of Sound.* **A. G. Webster.** (Roy. Inst. Proc. Advance proof. Received July, 1923.)—Some years ago it occurred to the author to devise an instrument that should be capable of measuring the intensity or loudness of any sound at any point in space, that should be self-contained and portable, and that should give its indications in absolute measure. By this is meant that the units should be such as do not depend on time, place, or the instrument, so that, though the instrument be destroyed and the observer dead, if his writings were preserved, another instrument could be constructed from the specifications and the same sound reproduced a hundred or a thousand years later. The difficulty comes from the fact that the forces and amounts of energy involved, even for very loud sounds, are extremely small. Thus, it needs about ten million cornets playing *fortissimo* to emit one horse-power of sound. Again, when a person is speaking in a loud tone, the pressure of the air varies by only a few millionths of an atmosphere. Further, the sound measurer must respond accurately to changes of *acoustic frequency*, as well as of this minute order of magnitude. There is, in addition, the problem of the reflection of sound by surfaces near the source and measurer; hence the law of this must be studied and the effects allowed for.

A standard source of sound the author calls a *phone*, and his sound measurer he calls a *phonometer*. This latter is shown in perspective views and in detail by a number of diagrams. To obtain the sensitiveness needed for ordinary sounds, the property of resonance is employed twice. First, a diaphragm responds better to a sound because tuned nearly to it; and, second, a resonator that can be tuned is put behind the diaphragm. The movement of the diaphragm is recorded for actual measurements by a thin steel torsion strip carrying a concave mirror. A lamp with a vertical straight filament is viewed through a telescope into which the small mirror focuses the image of the filament; a magnification of 1200 to 1500 is used. The instrument is calibrated by the use of a Michelson interferometer. E. H. B.

1906. *Speed of Small Explosion Waves in Sea Water and its Variation with Temperature.* **A. B. Wood, H. E. Browne,** and **C. Cochrane.** (Roy. Soc., Proc. 103. pp. 284–303, May 3, 1923.)—An accurate determination of the speed of explosion waves in sea water is here described. Four microphone receivers are laid on the sea bed at intervals of about four miles in a line approximately north and south. The time intervals of passage of the explosion wave between the various pairs of hydrophones are obtained by means of four strings of a six-stringed Einthoven galvanometer photographic arrangement. A fifth string is operated by the half-second ticks of a chronometer. The sixth string is reserved for recording a wireless signal sent from a destroyer at the instant of firing a charge. The more important results are as follows:

$V = (4955{\cdot}5 \pm 1)$ ft./sec. at $(16^{\circ}{\cdot}95 \pm 0^{\circ}{\cdot}1)$ C. and salinity $35^{0}/_{00}$.
$V = (4836 \pm 2)$ ft./sec. at $(6^{\circ}{\cdot}0 \pm 0^{\circ}{\cdot}1)$ C. and salinity $35{\cdot}1^{0}/_{00}$.
$V = (4847 \pm 1{\cdot}5)$ ft./sec. at $(7^{\circ}{\cdot}0 \pm 0^{\circ}{\cdot}1)$ C. and salinity $35{\cdot}2^{0}/_{00}$.

These give a mean temperature coefficient of the speed 10·9 ft./sec. per degree centigrade between 6° and 17° C. The salinity coefficient of the speed is approximately (3 to 4) ft./sec. per $1^{\circ}/_{\circ\circ}$ increase in salinity. No change in speed has been detected for charges varying in weight from 9 ozs. to 300 lbs. of explosive, the distance from the charge to the mid-point of the sub-base being approximately five miles. No variation of speed with depth has been detected. The coefficient of adiabatic compressibility of sea water at 16°·95 C. and $35^{\circ}/_{\circ\circ}$ has been calculated to be $C_{\phi} = (42\cdot744 \pm 0\cdot02) \times 10^{-6}$ per megabar. Combining this with Ekman's value of $C_{\theta} = (43\cdot145 \times 10^{-6}$ per megabar), the ratio of specific heats of sea water under these conditions of temperature and salinity and a mean pressure of two atmospheres is found to be

$$\gamma = 1\cdot0094 \pm 0\cdot0005$$

in good agreement with $\gamma = 1\cdot0090$ as obtained from thermodynamic data. E. H. B.

1907. *Design of Submarine Acoustic Signalling Apparatus.* **W. Hahnemann.** (Inst. Radio Eng., Proc. 11. pp. 9–25, Feb., 1923.)—A discussion is first given of the analogy between electrical oscillatory systems, including both the closed circuits which serve for the transformation of energy and the radiating systems serving for the transfer of energy to the medium, and the mechanical oscillatory systems used in acoustic signalling. It is then shown how the theory and design of acoustic transmitters and receivers can be simplified by means of these analogies. Mechanical systems consisting of two masses attached to one another by a spring of negligible mass may be coupled together by making one of the masses common to two such systems, and such an arrangement gives a "coupling" formula identical in form with the ordinary formula for the coupling of two electrical circuits of inductances L_1, L_2, and mutual M. The design of submarine signalling transmitters and receivers is then dealt with, and actual installations developed by the Signalgesellschaft, Kiel, are described. A. W.

1908. *Vowel Sounds.* **R. A. S. Paget.** (Roy. Soc., Proc. 102. pp. 752–765, March 1, 1923.)—Very full and illustrated account of the work given in Abstract 1187 ~~(1923).~~ E. H. B.

1909. *Minimum Intensity for Audition.* **F. W. Kranz.** (Phys. Rev. 21. pp. 573–584, May, 1923.)—(1) With the *thermophone* as source: the receiver was held to the ear like a telephone receiver and was actuated by a current from an oscillator, the threshold intensity being calculated from the corresponding current by Wente's formula. Tests of 14 ears for frequencies an octave apart show logarithmic sensitivities lying between those of Wien and those of Fletcher and Wegel, the mean values increasing from 5 for 128 v. per sec. to a practically constant sensitivity of about 8·5 for the range 512 to 4096 v. per sec. (2) With *telephone* receiver as source, a slightly lower sensitivity was obtained. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1910. *Longitudinal and Transverse Masses of the Electron.* **L. T. Jones and W. C. Pomeroy.** (Phil. Mag. 45. pp. 760–768, April, 1923.)—Since the first work of Kaufmann demonstrating the mass of the electron to be a function of the velocity much experimental work has been carried out by various physicists to verify the law of variation. In each case the method has involved only the transverse mass. The first suggestion of an experimental method involving the longitudinal mass was made by Einstein (Ann. d. Physik, xxxi. p. 583). The equations derived in the present paper are based on an experimental method by which the expressions for the longitudinal and transverse masses of the electron may be verified, not only for the Lorentz-Einstein electron but for those of Abraham, Walker, and Bucherer-Langevin as well. A. B. W.

1911. *Radiation from Accelerated Electrons.* **G. A. Schott.** (Phil. Mag. 45. pp. 769–777, April, 1923.)—The author discusses references in a recent letter and an earlier article by S. R. Milner [see Abstract 350 (1923)] to a solution obtained by the former in his Adams's Prize Essay of 1908, but treated more completely in his book on "Electromagnetic Radiation," and also a reference in the article to a paper by Born [Abstract 1723 (1909)]. The principal conclusions of the present paper are: (1) The hyperbolic motion of the electron considered in "Electromagnetic Radiation" and also in Milner's article involves no contradiction of the principle of the conservation of energy, provided that it be generated in any way which is consistent with the conservation of its electric charge and the continuity of its velocity. (2) The only class of motions unaffected by radiation is that in which the path of the electron is an hyperbola described with a constant velocity component parallel to the conjugate axis. The hyperbolic motion of Born is a special case, in which the transverse velocity is zero. In these motions the radiation is defrayed entirely at the expense of the acceleration energy of the electron. G. W. DE T.

1912. *Quantum Orbits of an Electron in Weyl's Space Time.* **E. Schrödinger.** (Zeits. f. Physik, 12. 1 and 2. pp. 13–23, 1922.)—The paper is a mathematical discussion of the quantum orbits of a single electron in Weyl's extension of Riemann's fourfold into a space time in which the measure determination of the world points remains that of the original quadratic differential form $\sum g_{ik}dx_i dx_k (i, k = 1, 2, 3, 4)$, retained by Einstein, and in addition, the metrical relationship of the world points is defined by the linear differential form $\sum \phi_i dx_i$ $(i = 1, 2, 3, 4)$. G. W. DE T.

1913. *Electromagnetic Mass of the Electron.* **E. C. Stoner.** (Cambridge Phil. Soc., Proc. 21. pp. 552–555, June 15, 1923.)—Consider the Lorentz electron with a surface charge of uniform density σ. The electromagnetic rest-mass is found to be given by $m_0 = 4W_E/3c^2$, where W_E is the electrostatic energy of the electron. The relativity theory gives $m_0 = W/c^2$, where W is the rest energy of the electron. This suggests the electron possessing energy other then electrostatic. The author shows that if the electron is maintained in equilibrium by a stress system producing a force of $2\pi\sigma^2$ per unit area, it would possess internal potential energy of precisely this amount. (See Eddington, "Mathematical Theory of Relativity," Section 76.) G. W. DE T.

1914. *Mutual Electromagnetic Momentum and Energy of a System of Moving Charges.* **I. Roman.** (Nat. Acad. Sci., Proc. 9. pp. 165–166, May, 1923.)—The momentum and the energy of an electric field due to a system of moving charges differ from the sums for the separate charges by a quantity called the "mutual momentum," or the "mutual energy," respectively. These quantities are calculated in the paper for a system made up of two charges, and inspection of the results leads to the conclusion that the mutual momentum is parallel to the velocity only in the cases for which the pair of charges moves parallel or normal to their common line. However, the mutual momentum is always in the plane containing the two charges and the direction of motion. For more than two charges, the mutual effect may be treated as the sum of the effects for all possible pairs, due to the quadratic property of the momentum and energy. The results have application in the study of "packing effect" in atomic structure. H. H. Ho.

1915. *Electromagnetic Mass.* **E. Fermi.** (N. Cimento, 25. pp. 159–170, 1923.) Abraham's rigid electron gave a limiting value $\frac{4}{3}u/c^2$ to the mass; Lorentz's contractile electron undergoing FitzGerald's contraction gave again this value $\frac{4}{3}u/c^2$, but the corrections for value of v were different. The theory of relativity would give u/c^2. The author shows that on relativity principles a contractile electron gives u/c^2; application of Hamilton's principle. A. D.

1916. *The Wommelsdorf Condenser Machine.* **H. Henning.** (Elek. u. Maschinenbau, 41. pp. 84–85, April 15, 1923. Suppt.)—A description, with illustrations, of an influence machine of a new form. The discs are rotated between charged sectors, and the accumulated + and − charges on the discs are collected from the extreme rim. Spark-lengths of great length are claimed for these machines, being as much as 90 % longer than those given by equivalent Wimshurst machines. P. E. S.

1917. *The Vectors of the Electromagnetic Field.* **O. Franke.** (Elek. u Maschinenbau. 41. pp. 277–283, May 13, 1923.)—The discussion by the Société Française de Physique (Elek. u. Maschinenbau, 40. pp. 380–382, Aug. 6, 1923) concerning the identity of magnetic field strength and magnetic induction, led to no conclusive results. The author therefore investigates the fundamental equations of the electromagnetic field with special reference to this problem. Whereas the displacement vector D actually describes the influence effect of the electrostatic field, and the vector B the induction effect of the electromagnetic field, both appear in Maxwell as forces per unit charge or per unit pole strength, characterised by the vectors of the electrical and magnetic field strengths E and H. In certain cases D can be measured by E, and B by H, or vice versa, but, without hypothetical assumptions, neither the influence nor the induction effect can be referred to the other effects of the field. In addition to these considerations the author deals with the analogies and the differences between the properties of the electrostatic and electromagnetic fields.

R. E. N.

1918. *The Field of Force in the Polarised Dielectric of a Spherical Condenser.* **A. Caldi.** (Accad. Sci. Torino, Atti, 57. 6 and 7. pp. 129–146, 1921–1922.)—The author gives a mathematical investigation of the nature of the field of force existing in the polarised dielectric of the spherical condenser, and deduces for that field by Somigliana's method of calculation [Abstract 159 (1910)] the system of elastic tensions reproducing the electric field and the system of the displacements and deformations resulting in the dielectric which are rendered manifest experimentally by the phenomena of electrostriction. These last—theoretically deduced—are compared with those observed experimentally by Quincke in spherical condensers.

J. J. S.

1919. *Apparent Effect of the Sun's Electrical Charge on the Yearly Variation of Atmospheric Potential Gradient.* **F. Sanford.** (Science, 57. pp. 616–618, May 25, 1923.)—The author briefly considers the curves representing the annual variation of atmospheric potential gradient and "earth-air" current at places in different latitudes, in relation to the corresponding yearly variation of solar altitude. The results appear to him to show that the yearly variation of potential gradient (or, better, of "earth-air" current) is such as would be expected to result from a negatively charged earth under the inductive influence of a similarly electrified sun.

M. A. G.

DISCHARGE AND OSCILLATIONS

1920. *Mass Spectra.* **F. W. Aston.** (Phil. Mag. 45. pp. 934–945, May, 1923.)—The list of elements examined is now extended to include Ni, Se, Sn, Fe, Al, Sb. Improved plates are now being employed, which have been "Schumannised." Helium from the Canadian gas-wells was investigated, and found to have no isotopes; a search was also made for the He^{++} atom; since the 2nd order line of He would be just separated from the hydrogen molecule line, an accurate measure of the relative masses would be possible. No lines were obtained, however; it is suggested that the ionisation potential of He^{++} is so large that an inappreciable number can pass through the apparatus without collision.

Nickel.—Nickel carbonyl was employed diluted with CO_2 to avoid undue deposition on the walls. There are two isotopes, 58 and 60. Chlorides were found to be hopeless owing to the chlorine attacking every element present in the tube, electrodes, etc., and so forming a maze of lines.

Xenon.—Two new lines are found for xenon at 124, 126.

Tin.—Tin tetramethide was used; tin has 7 istopes 116–120, 122, 124, and possibly an eighth at 121. These numbers are integers compared with each other, but compared with xenon, they give values less than integers by 2 or 3 parts in 1000. There is apparently no doubt that xenon and tin cannot both have exactly whole-number values, though the divergence is slight.

Iron.—Examined as the carbonyl, and is apparently a single element.

Selenium.—This element was volatilised by concentrating on it a beam of kathode rays. It gave rise to 5 strong lines at 76, 77, 78, 80, 82, and a weak one at 74.

Aluminium was used as the volatile chloride, and it was found to be a single element, mass 27.

Antimony was used as antimony methide vapour, mixed with CO_2. It gave two strong components at 121, 123, showing that the international atomic weight, 120·2, is much too low; while Willard and McAlpine's value 121·77 is in agreement.

Chlorine was examined indirectly when dealing with aluminium chloride; it is now clear that the number 39 must be excluded from the isotopes of chlorine. A complete table of 34 elements is given.

A. C. M.

1921. *Rotation of the Electric Discharge in a Magnetic Field. Determination of Molecular Diameters.* **C. E. Guye** and **R. Rudy.** (Arch. des Sciences, 5. pp. 182–196, May–June, 1923.)—The movement of charged particles (luminous discharge) is here investigated as they are displaced under the simultaneous influence of an electric field and a magnetic field perpendicular to it. The rotation of the discharge is considered from the point of view of ionisation by collision which enables a relation to be established between the velocity of rotation and the molecular diameters. The diameters calculated according to the velocities of rotation observed are found of the same order of magnitude as those obtained from experiments on the viscosity of gases. These experiments have clearly shown the great importance which attaches to the purification of the gas if exact results are desired. The paper is divided into three sections. The first deals with the movements of electrified particles when acted upon by an electric field and a transverse magnetic field; rotation of electrons; rotation of ions. This is of a theoretical nature and is mainly mathematical. In the second part a detailed description of the experimental arrangement is given with a diagram showing the parts and connections. The third section is devoted to an account of the preparation of the gas in a pure state, and the following are the cases considered: Nitrogen, oxygen, hydrogen, CO_2, CO, N_2O, NO, sulphuric anhydride, methane, and ethylene.

A. E. G.

1922. *Cathodoluminescence and Molecular Aggregation.* **J. Ewles.** (Phil. Mag. 45. pp. 957–968, May, 1923.)—Experiments were made to determine if a minimum velocity of the kathode rays existed below which luminosity could not be excited. Twenty metallic oxides were investigated, and several other substances. The material was deposited on a thin strip of platinum, which was then introduced into a vacuum flask, so as to be at the focus of a concave kathode. The tube was excited by a Mercedes electrostatic machine, and potentials measured with a Kelvin and White electrostatic voltmeter. A minimum potential was found for each substance showing that a definite quantum is required to excite luminescence.

No simple relation exists between the minimum voltage and the atomic numbers of the metals involved, suggesting that the cause is not atomic. A very large body of evidence is cited to substantiate the suggestion that the ultimate cause is a change in the state of molecular aggregation of the substance concerned, resulting in a configuration having less energy; the balance of the energy appears in the form of the emitted radiation. To make this certain, minimum voltage experiments were made with substances (among others α and β quartzite) which are known to change their state of molecular aggregation at definite temperatures. The platinum strip was now arranged so that it could be heated by an auxiliary electric current. This current was calibrated to give the temperature of the strip. In this way the substance could be heated above the temperature of change of state of aggregation, and then exposed to the bombardment of the kathode rays. Luminescence was then absent, whatever the applied potential.

The temperature at which fluorescence disappeared was determined and was in all cases nearly that of transformation. Multiplying the minimum potential by the electronic charge, the energy per electron is obtained; assuming that one such quantum is required per molecular aggregate, the author calculates the number of molecules in the aggregate, and arrives at numbers of the order of 2000. The results so far obtained are regarded as rough, so that great reliance is not placed on the exact numbers. A. C. M.

1923. *Researches on the Kathodic Phosphorescence of Rubies.* **J. Rossignol.** (Comptes Rendus, 176. pp. 1459–1461, May 22, 1923.)—The object of this investigation has been to find the influence of the speed of the exciting kathodic electrons on the law of decrease of the phosphorescence of rubies. Experimental details of the photometric measurements are given. Six synthetic rubies were employed of compositions 0·1, 0·5, 1, 2·5, 5, and 10 parts respectively of Cr_2O_3 per 100 of Al_2O_3. The principal results are shown clearly on curves whose ordinates are given by $1/\sqrt{I}$, where I represents a luminous intensity factor, with times as abscissæ. For the same ruby the initial luminous intensity appears independent of the emission voltage V of kathodic rays. The curves relating to the same ruby issue from practically a common point. Becquerel's law is only verified asymptotically. For the same potential and different rubies there exists in the vicinity of 0·5 of Cr_2O_3, an optimum value for the duration of phosphorescence. These results are difficult to interpret theoretically, and this appears to be due to the fact that in the spectrum of the ruby, the two fundamental red rays are due to resonance (which the author has verified directly) and that the superficial layers must absorb a part of the radiation emitted by the deeper layers affected by the kathodic electrons. H. H. Ho.

1924. *Neutralisation of Hydrogen Nuclei in Canal Rays.* **E. Rüchardt.** (Zeits. f. Physik, 15. 2 and 3. pp. 164–171, 1923.)—The measurement of the mean free path of change of charge of the hydrogen canal rays in H_2, N_2, and O_2 has for the positive free path L_1 led to specially simple results. L_1 is that mean free path in cm. which a hydrogen nucleus in one of the mentioned gases traverses before it forms a neutral H atom through taking up of an electron. It was found that L_1 is approximately independent of the nature of the gas, but on the contrary strongly increases with increase of the velocity of the rays. It appears as if the taking up of an electron by the nucleus may be solely a function of the velocity of the H-rays. That it does not depend upon the nature of the gas is intelligible when it is considered that the ionisation work which the nucleus has to perform is only a small fraction of the kinetic energy of the nucleus. The present paper gives an account of calculations which were made to investigate the conditions which determine whether the electron split off from the gas molecule attaches itself to the nucleus or not.

The number of collisions of hydrogen nuclei in the canal rays with the molecules H_2, N_2, and O_2, which lead to the taking up of an electron, may be calculated if it is assumed that the conditions of attachment may be expressed thus:

$$\frac{mv^2}{2} \leqq \frac{e^2}{r},$$

$$r \geqq r_1,$$

where m is the mass and e the charge of the electron, v the velocity of the rays, and r_1 the radius of the first Bohr's orbit in the hydrogen atom. The same conditions lead to a satisfactory explanation of the limit of path of the α-rays if it is considered that the nucleus charge E here $= 2e$, and r_1 is half as great as in the H atom. The critical velocity calculated for the α-particles is $v_0 = 6 \cdot 15 \times 10^8$ cm./sec. Only when the velocity is less than this value can attachment of an electron take place. J. J. S.

1925. *Discharge in Dissociated Gases.* **R. Seeliger.** (Zeits. f. Physik, 15. 1. pp. 27–30, 1923.)—The author has been investigating for some time the influence of impurities in the filling gases on the glow discharge, and, while unable to publish his results at the moment, he offers some remarks on a recent publication by Wood [see Abstract 53 (1923)] on the same lines. The author's work has indicated that the carrier of the many-lined spectrum of hydrogen is the molecule, and that only the Balmer series is given by pure water-vapour. Wood finds that the diatomic gases, nitrogen and hydrogen, are much dissociated in the discharge when sufficient current strengths are employed, and that by the catalytic effect of the glass walls of the discharge vessel the reformation of molecules from atoms is favoured. This catalytic effect is poisoned by traces of oxygen or water-vapour. The author states that hydrochloric and vapour is likewise a catalytic poison, and that the whole phenomenon provides a very rational explanation of many hitherto obscure effects, since by poisoning the surface of the discharge vessel the dissociation equilibrium is displaced. An example is given where the potential gradient in the positive column in pure nitrogen is greater than by addition of very small quantities of oxygen, although an increase might be anticipated. A second example is discussed at length of the red layers in hydrogen studied by Neubert, while several similar phenomena are opined to be now explicable from this new standpoint. H. H. HO.

1926. *The Distribution of Energy about the Kathode in Glow Discharge.* **A. Günther-Schulze.** (Zeits. f. Physik, 15. 1. pp. 8–23, 1923.)—The author describes experiments in which the ratio between the energy delivered to the kathode and the total energy of the kathode-fall was measured. In one method an iron sphere, used as kathode, was heated to red heat by the glow discharge. It was then heated to the same temperature, as the anode of a mercury arc, the anode drop was measured with a probe electrode, and thus the energy required to obtain the particular temperature was determined. In the second method the change in resistance caused by the glow discharge in a kathode formed of a strip of thin platinum foil was measured, and the energy required to produce this change of resistance determined by sending a current through the strip; the first method showed that in argon at 1·83 mm. 72 % of the energy went to the kathode, and in hydrogen at 2·37 mm. 39 %; the second method gave with nitrogen and hydrogen 27 % to 70 % according to the pressure. A rough calculation of the percentage, if the temperature in the Crookes's dark space is about that of the outside air, gives a value of not more than 20 %, the positive ions making about 20 collisions in their passage through the dark space. The experiments show that the number of collisions must be much smaller than this, as a certain proportion of the energy of " fall " is given up at each collision and fails to reach the kathode. The observed velocities of canal rays lead to the same conclusion; and the obvious explanation is that the temperature of the dark space is high. An exact determination is impossible; but the author's approximate calculation leads to the value 720° C. It is shown that the portion of the energy of the kathode-fall given to the dark space is more than sufficient to heat it to this temperature. The free path of the electrons from the kathode is four times as great as that of the positive ions (kations), so that most of the electrons pass through the dark space without collision, and ionise the gas in the negative glow; each electron has sufficient energy to ionise a number of molecules. It follows that the ratio of the electron current to the kation current in the dark space is of the order 1 : 10. H. N. A.

1927. *Theory of the Positive Column.* **A. Partzsch.** (Zeits. f. Physik, 14. 3 and 4. pp. 191–203, 1923.)—On the assumption that the quantity of new ions generated by collision in the positive column for a certain current and width of tube is independent of the pressure, a new law can be formulated on the basis of Townsend's theory of ionisation by collision. From this law it follows that the gradient with low pressure reaches a minimum and then with a further decrease of pressure it again rises. The product N.V. of the number of collisions and the mean ionising tension deviates in the case of hydrogen only slightly from that found by Townsend. The given deviation in the case of nitrogen is explained by an admixture of hydrogen. The number a of the ionising collisions is of the same order of magnitude in hydrogen and nitrogen for a given current and tube width. From the number a can be calculated the useful effect of the positive column as light rays; little deviating from the Ångström measurements, it diminishes with increasing pressure. A. E. G.

1928. *The Anode-Fall and the Dependence of the Gradient on the Current.* **A. Partzsch.** (Zeits. f. Physik, 15. 4 and 5. pp. 287–306, 1923.)—The dependence of the anode-fall upon the pressure in mercury-vapour and hydrogen is investigated. The anode-fall increases constantly in both gases from about 0·4 mm. Hg. In mercury-vapour the anode-fall approximates with increasing pressure and current to a limit of 3·72 volts, which is in agreement with the work of Schüler, as the difference between the ionising tension 10·39 volts and the exciting tension 6·67 volts shows.

According to the published accounts of observations there is a further limiting value of the anode-fall at 2·7 volts, but this is only possible when the anode lies in the kathode pencil of the mercury arc-light. The anode-fall in hydrogen amounts to 17·6 volts and is about 1·2 volt greater than the ionising tension. In nitrogen the value is 19 volts, which is about 2 volts greater than the ionising tension. The anode-fall in argon and neon approximate with increasing current strength to the lowest exciting tension, while with smaller currents the anode-fall equals the ionising tension of these gases. In argon the anode-fall with lowest exciting tension may be essentially below the latter. No explanation of this is offered. The dependence of the gradient on the current is satisfactorily shown by the formula $X = a + b/(c + i)$. The constant c appears from the researches up to date to be moderately independent of the gas and the pressure; i = current in amp. A. E. G.

1929. *Kathode-Fall and Glow Current Strength in Mercury-Vapour.* **A. Günther-Schulze.** (Zeits. f. Physik, 15. 4 and 5. pp. 244–253, 1923.) —After a description of the method of carrying out the experiments the following points are dealt with: (1) Normal kathode-fall, (2) current density of normal kathode-falls, (3) width of the fall space (Crookes's dark space) with normal kathode-fall, (4) influence of the addition of foreign gas, (5) theoretical considerations. The following results are obtained: The connection between glow current strength and kathode-fall depends largely upon the form and size of the vacuum vessel employed. The normal kathode-fall at an iron kathode from which the gas has been thoroughly removed by evacuating for several hours at a bright red glow is found to average 533 volts. In the regions of abnormal kathode-falls the kathode-fall rises with the current density in mercury-vapour, being very much quicker than in hydrogen and air at equal pressure. The addition of hydrogen and air to mercury-vapour alters both the normal kathode-fall and also the current-density of the abnormal kathode-falls at first noticeable, when the partial pressure has become just about equal to that of the mercury-vapour. A. E. G.

1930. *Ionisation and Resonance Potentials.* **W. A. Noyes, Jr.** (Science, 57. pp. 314–318, March 16, 1923. Paper read before the Am. Assoc. for Adv. of Science.)—A survey of the present position. W. R. C.

1931. *Excitation and Ionisation Potentials o Neon and Argon.* (Appendix). **G. Hertz.** (K. Akad, Amsterdam, Proc. 25. 9 and 10. p. 442, 1923. In English.)—Franck's value of 20·45 v. for the first excitation potential of helium is corrected in view of other later work to 19·75 v. This necessitates a correction of the excitation and ionisation potentials of neon and argon giving the values:

Neon:	Excitation potentials: 16·65 and 18·45 v.
	Ionisation potential: 21·5 v.
Argon:	Excitation potentials: 11·55, 13·0, and 14·0 v.
	Ionisation potential: 15·3 v.

The conclusions relating to the optical spectrum are not affected by this correction. [See Abstract 673 (1923).] A. B. C. L.

1932. *Ionisation by Collision in Helium.* **J. Townsend.** (Phil. Mag. 45. pp. 1071–1079, May, 1923.)—A discussion of the results obtained by the parallel-plate method [see Abstract 1246 (1912)] and the valve method for the determination of the ionisation potentials of the monatomic gases. Experiments were made with helium by the first-named method, obtaining points on the current-potential curve closer together than previously, and also smaller potentials were used, so as to investigate more closely the initial effects. It is concluded that the energy required to ionise a molecule of helium is about 12 volts, and that the sum of the energies of the electron which ionises the molecule and the electron set free from the molecule after collision is about 16·6 volts. This conflicts with the results of valve experiments. A. C. M.

1933. *Hysteresis Phenomena in Glow Tubes.* **A. Rüttenauer.** (Zeits. f. Physik, 15. 1. pp. 33–39, 1923.)—The characteristic of the negative glow-light of the Osram glow-lamp possesses a hysteresis with which the descending branch of the hysteresis loop may lie either above or below the ascending branch. In a few cases the glow-lamps have a characteristic without hysteresis. The potential difference between increasing and decreasing current amounts to only a few volts, on the average 0·5 to 3. Observations are recorded and characteristic curves given for the case of tubes filled with a mixture of neon and helium gases (75 % neon, 25 % helium) at 10 mm., the measurements being taken at various periods during a burning duration of 4000 hours.

The author considers that whatever explanation may be adopted for the formation of the hysteresis impurity of the gas is always returned to as being the primary cause. J. J. S.

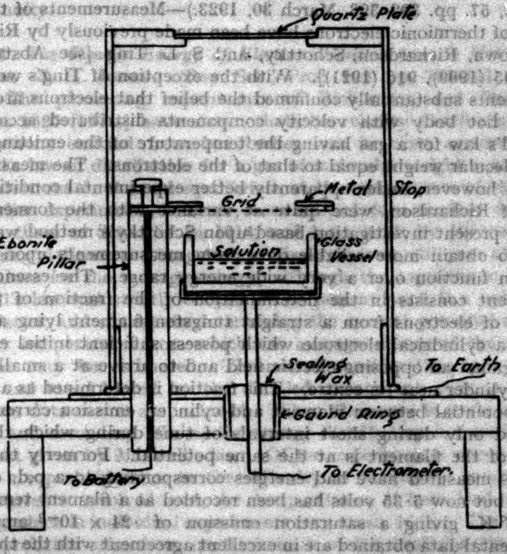
1934. *Luminescence of Phosphores in Strong Electric Fields.* **F. Schmidt.** (Ann. d. Physik, 70. 3. pp. 161–198, Feb. 15, 1923.)—The investigations of Gudden and Pohl [Abstract 450 (1921)] on the excitation of phosphores by powerful electric fields are extended to a number of different phosphores of known composition, the variation of the illumination with the strength of field being followed qualitatively and quantitatively.

The imposition of an electric field during the decay of a phosphore causes a short-lived illumination, whilst, if the decay proceeds for a longer time under the influence of the field, removal of the latter induces persistent illumination of the phosphore. When the illumination of a phosphore has disappeared under the action of the field, it may be immediately restored by reversal of the direction of the field. The brightness of the illumination of a phosphore by a field applied at a definite interval after excitation increases with the strength of the field.

If the phosphore is excited in an electric field and the latter removed during the subsequent decay, a transitory illumination is observed, the intensity of this increasing with the strength of the field. The results of the quantitative measurements are given in full. The action of the electric field on a phosphore during decay may be regarded as an acceleration of the decay by rotation of the polarised atom-pairs, either alone or in conjunction with a rotation of the whole centre. When the electric field acts on the phosphore during the excitation, the processes taking place in the centres become considerably more involved, but may be explained in relation to the experimental results obtained. T. H. P.

1935. *The Normal and Inverse Photoelectric Effect with Submicroscopical Particles.* **M. Hake.** (Zeits. f. Physik, 15. 2 and 3. pp. 110–120, 1923.)—Ehrenhaft's condenser method was employed, minute test bodies being produced in a quartz glass tube by sublimation and condensation. Non-metals were examined in dry, dust-free air, and the particles that had an electric charge were removed by charging the condenser plates. Light from a mercury-vapour lamp was admitted, and the test particles moved towards one or other of the condenser plates according to their charge. Selenium and tellurium, which exist in different forms, show normal and inverse effects; oil of turpentine, which is inactive in large quantities, is so also as a fine mist; waterdrops bound on condensation nuclei are inverse; the soot formed by burning turpentine oil is normal; some substances are not charged after long illumination. It was shown experimentally that dry, dust-free air was not ionised by rays of wave-length about 250 $\mu\mu$, and that when the condenser plates were also illuminated no change took place in the observations. For metals experiments were made in N, CO_2, H, and A, and non-metals were also tested in these gases. In N positively charged particles (Au, Ag, Hg, Cu, Bi, Se, I) do not change their charge when illuminated with the mercury-vapour lamp; many negative metal particles, produced by heating or ultra-violet radiation, lose their charge entirely when thus illuminated; the particles of various dielectrics and semi-conductors do not lose their negative charge when illuminated. It does not appear that the inverse charges are due to picking up electrons; first because the surrounding gas is not ionised by ultra-violet rays of this wave-length, and so electrons are not available; and second because the positively charged particles, which could easily pick up electrons, are not discharged. In CO_2 the number of + particles is small, many substances are only inverse; most of the + Te, Hg, and Zn particles are large (10^{-4} to 10^{-5} cm.); Bi, however, shows only normal photo-effect; the particles are less sensitive than in air and N, with large masses of material the contrary is true; many substances, which otherwise give only the inverse effect, are charged positively; this is due to the fact that CO_2 is ionised by wave-lengths larger than 180 $\mu\mu$, which is not the case with N_2 and O_2. The experiments with argon make it clear that the inverse effect is not due to chemical combination with the gas. It appears that it can only be explained by a loss of positive electricity. H. N. A.

1936. *Variation of the Photoelectric Activity of a Potassium Ferro-Cyanide Solution with the Concentration of the Solution.* **J. H. J. Poole.** (Phil. Mag. 45. pp. 895–906, May, 1923.)—In any dissolved salt there are three possible sources of the photoelectron: (1) The positive ion (2) the negative ion, (3) the undissociated molecule. The shape of the curve connecting the activity of the solution with the concentration will depend on which of these three possible origins is the real one. If one radicle of the salt is photoelectric, the law connecting activity with concentration should be a simple linear one. For the experiments a mercury-arc in quartz was used as a source of light, a Dolezalek quadrat electrometer in conjunction with a special form of ionisation vessel being used to measure the electronic current from the solution. A sketch of the general arrangement is shown herewith. The underside of the glass vessel is covered with tin foil, and electrical connection with this tin foil and the solution is made by a piece of platinum ribbon passing over the upper edge of the vessel and dipping into the solution. The various precautions taken and the method of conducting the experiments is described very minutely. The actual average value of the electronic current per sq. cm. is about 8×10^{-14} amperes, or about 5×10^{5} electrons per sec. If a layer only 10^{-8} cm. thick of the solution is affected, only about one molecule in 10^{7} of the potassium ferro-cyanide in this layer emits an electron every second. The curve obtained by plotting activity against concentration is at the lower concentrations a simple linear function of the concentration, but for stronger solutions the activity increases more rapidly than the concentration. The author considers the problem mathematically, and concludes (1) that the negative radicle is probably responsible for the photoelectric properties of the solution and (2) that the relative increase of activity of the stronger solutions cannot be accounted for either by the possible effects of the range of the photoelectron in the solution or by the increase in the number of undissociated molecules per c.c. of the solution. T. C. H.



1937. *The Relation between Illumination and Photo-Current in Alkali Metal Cells.* **H. v. Halban and L. Ebert.** (Zeits. f. Physik, 14. 3 and 4. pp. 182–190, 1923.)—E. Steinke found, with an argon-filled potassium cell, that the relation between illumination and photo-current was by no means one of strict proportionality, even when the cell was used with moderate currents [Abstract 900 (1923)]. The authors have investigated five different cells, and come to the conclusion that the cell used by Steinke was an exceptional one, and that most cells show fairly close proportionality between I and i. They point out, however, that Steinke's experiments show that it is necessary to investigate the properties of a cell before using it for measurements, and express the opinion that for accurate work the use of abnormal cells should be avoided. **H. N. A.**

1938. *Photoelectric Currents.* **W. Dällenbach and G. Jahn.** (Phys. Zeits. 24. pp. 265–269, June 15, 1923.)—Facts and arguments are brought forward against the correctness of the views of Schenkel and Schottky who claim to have measured photoelectric currents of 100 amperes. **J. J. S.**

1939. *The Initial Energy of Thermionic Electrons.* **L. H. Germer.** (Science, 57. pp. 392–393, March 30, 1923.)—Measurements of the initial energy of thermionic electrons have been made previously by Richardson and Brown, Richardson, Schottky, and S. L. Ting [see Abstracts 678 and 2095 (1909), 916 (1921)]. With the exception of Ting's work, these experiments substantially confirmed the belief that electrons are emitted from a hot body with velocity components distributed according to Maxwell's law for a gas having the temperature of the emitting surface and molecular weight equal to that of the electrons. The measurements of Ting, however, under apparently better experimental conditions than those of Richardson, were quite at variance with the former results, and the present investigation based upon Schottky's method was undertaken to obtain more reliable data from measurements upon the distribution function over a very wide energy range. The essence of the experiment consists in the determination of the fraction of the total number of electrons from a straight tungsten filament lying along the axis of a cylindrical electrode which possess sufficient initial energy to move against an opposing electric field and to arrive at a small opening in the cylinder near its centre. This fraction is determined as a function of the potential between filament and cylinder, emission currents being measured only during short intervals of time during which the entire surface of the filament is at the same potential. Formerly the fastest electrons measured have had energies corresponding to a p.d. of about 2 volts, but now 5·35 volts has been recorded at a filament temperature of 2475° K. giving a saturation emission of $\cdot 24 \times 10^{-8}$ amp. The experimental data obtained are in excellent agreement with the theoretical equation derived by Schottky. Measurements have yet to be made at considerably higher temperatures where it seems probable that the distribution function can be investigated as far as 6-volt electrons. **H. H. Ho.**

1940. *Emission of Secondary Electrons by the Passage of Canal Rays via Solid Bodies.* **J. Hahn.** (Zeits. f. Physik, 14. 6. pp. 355–368, 1923.)—Reference is made to previous work on this subject. The experimental arrangement now used is described and illustrated in detail. It is briefly a modification of apparatus used by J. J. Thomson and others. The rays are caused to penetrate gold foil. Experimental curves are given for electron emission at various voltages and then a mathematical analysis of these curves. A summary of results is briefly as follows: (1) With increasing primary voltage the emission of secondary electrons rises according to a law which appears to be very similar to Richardson's law for the emission of electrons from heated filaments in relation to temperature. (2) Together with the emission of secondary electrons a positive secondary radiation was observed which apparently depends upon the destruction of the gold foil by canal rays. (3) The measurement of the velocities of the secondary electrons gave a relation of canal rays and secondary electron velocities most noticeable at smaller velocities, the electrons at higher velocities being relatively fewer. With increased velocities of the primary canal rays the percentage of small velocity electrons diminished (by their acquiring higher velocities) but so that the majority of electrons were still of small velocity. (4) A comparison of the electron quantity emitted by the canal rays on both sides of the foil shows this approaches unity, for the values of voltages used (25,000–30,000), but it is possible this relation may, under certain conditions, exceed unity. B. J. L.

1941. *The Kinetic Energy of Electrons Emitted from a Hot Tungsten Filament.* **J. H. Jones.** (Roy. Soc., Proc. 102. pp. 734–751, March 1, 1923.)—The pioneering experiments of Richardson and Brown [see Abstract 1825 (1908)] have shown that the velocity distribution among the electrons emitted from hot bodies was in close agreement with Maxwell's law of distribution for a gas of molecular weight equal to that of the electrons in thermal equilibrium at the temperature of the source. The earlier experiments, however, were subject to a number of defects, as were those of Schottky in 1914, and later work by Richardson and Ting, using platinum and tungsten as emission sources, still gave abnormally high values for the average energy, although the logarithmic nature of Maxwell's law was strictly obeyed. The present work is a continuation of the latter, and consists in determining the current potential curves for different temperatures from which the average energy of the stream of electrons may be estimated. Theoretical considerations are first discussed and are followed by the detailed experiment account in which numerous data curves are included. When allowance is made for experimental and secondary effects, the energy distribution is found to agree with that given by Maxwell's law. Of the experimental errors the most serious are probably due to the difficulty of measuring accurately the small currents involved and the temperatures. These lead to uncertainties, which in individual experiments may attain 10 %. The secondary effects probably arise from contamination of the heated surfaces. This tends to increase the apparent energy of the electrons emitted, which may attain 20 %. The abnormal electron energies found by Ting, which were as much as 100 % in excess of Maxwell's distribution value, do not appear under satisfactory experimental conditions. H. H. Ho.

1942. *Motion of Electrons in Carbon Monoxide.* **H. B. Wahlin.** (Phys. Rev. 21. pp. 517–524, May, 1923.)—Formation of negative CO ions was found, in previous mobility experiments, to be extremely rare. This result has now been verified with CO generated by formic acid dripping into concentrated sulphuric acid and purified with great care. The very high mobilities obtained indicate clearly that an electron liberated in pure CO remains free. *Electron mobility as a function of field and pressure* was studied, using alternating potentials with frequencies up to 340,000 cycles, generated by a vacuum tube oscillating circuit. At a pressure of 723 mm. a mobility of 118 m./sec./volt/cm. was measured, which decreased to 81·5 m. as the field intensity increased from 4·5 to 48 volts/cm. The Townsend-Compton theory of mobility leads to the following equation for the speed of an electron in a field: $x : v = a(x/p)/\sqrt{B + (x/p)}$. This leads to a relation between frequency and critical value of the field X_1 which is found to agree with the results for CO if $a = 1{\cdot}87(10)^6$ and $B = 0{\cdot}005$, the pressure being in mm. Hg. This agreement suggests (1) that the mean free path is independent of the field, and (2) that the electron collisions with CO molecules are very inelastic. AUTHOR.

1943. *The Free Path of Slow Electrons in Gases.* **R. Minkowski** and **H. Sponer.** (Zeits. f. Physik, 15. 6. pp. 399–408, 1923.)—The electrons were produced by an incandescent tungsten kathode, accelerated by a positively charged cylinder of platinum gauze surrounding it, passed through the rarefied gas investigated, and caught by the surrounding cylindrical anode, which was at a slightly higher potential than the gauze cylinder. Argon, in which the increase of free path at low electron velocities was discovered by C. Ramsauer [Abstract 1494 (1922)] and by H. F. Meyer, was first investigated. The current-accelerating voltage curve shows a steep maximum at zero voltage, which depends on the long free path at small electron velocity; after a steep drop there is another sudden rise; this is at 11·2 volts, allowing for the space charge, and 0·3 volt is to be added for initial electron velocity and contact potential, so that the result agrees with the 11·5 volts required to excite the argon atom. There is evidence of a second excitation shown by a rise in the curve at 12·4 to 12·5 volts, or adding the 0·3 volts as above at 12·7 to 12·8 volts; this agrees with G. Hertz's value 13·0 volts. These results are not comparable with those of direct measurements; but it is remarkable that the anomaly of the free paths makes the points at which slow electrons are produced by inelastic collisions show up much more clearly than with gases in which the free path with slow electrons is short. There is then a fall in the curve, and another sharp rise at 15 volts, depending evidently on the ionisation of the argon; then another drop and a rise at 22·7 volts = 11·2 + 11·5 (nearly 11·5 + 11·5); still another at 24·7 volts, which implies two collisions in one of which 11·2 (+ 0·3) volts and in the other 13·0 volts are lost; finally there is a rise at 25·4 volts, or 13 volts above the 12·4 volt rise, which implies two collisions in each of which 13 volts are given up to argon atoms. Krypton shows very similar phenomena; a sharp rise at zero voltage, showing long free path for small velocity, a rise at about 6 volts, the first excitation point, another at 9 volts, the second. There is an unexplained hump in the curve between 1 and 2 volts, a similar hump being observed with xenon; this gas shows the sharp rise at zero volts, like argon and krypton, and a series of rises about 8 volts apart, due to the first excitation voltage; there is also a sign of a second excitation voltage between 8 and 9 volts. Neon and helium show only a small variation of the free path with the velocity. H. N. A.

1944. *Auto-Electronic Discharge.* **J. E. Lilienfeld.** (Zeits. f. Physik, 15. 1. pp. 46–50, 1923.)—An experiment is described which supports the former observation that in this effect the kathode is not warmed. A platinum wolfram thermoelement is used in which the wolfram at the junction is drawn out to a point and projects about 2 mm. When from this point the autoelectronic discharge takes place towards a water or ice-cooled hollow copper anode with platinum iridium mirror (several milliamperes at about 30 kilovolts) the thermoelement shows only small temperature changes, and in the experiments so far carried out, while the result is not decisive, cooling seems to take place. An improved arrangement with two junctions has also been used [Abstract 914 (1923)].

Characteristic curves of the discharge are also given showing the relation between potential and current with different distances of the electrodes. These the author considers support his former statement that for a given material a definite finite jump of potential is necessary in a distance from the kathode not exceeding a definite small amount, in order that the electrons may be set free, in contradistinction to a strong e.m.f. confined to an indefinitely small nearness to the kathode. In the two characteristic curves given the distances apart of the electrodes were 2·0 mm. and 0·2 mm. The potential varied between about 1100 and 3500 volts and the current varied from about 10^{-6} to 10^{-3} amp. As regards what would happen with still smaller distances between the electrodes the author considers there are two alternatives: either with diminution of distance something new will occur (action of dust) which will lessen the finite potential jump mentioned, or the rise of potential will remain in existence. J. J. S.

1945. *Auto-Electronic Discharge.* **W. Schottky.** (Zeits. f. Physik, 15. 1. p. 51, 1923.)—In remarks on the note by J. E. Lilienfeld (see preceding Abstract) the author considers that no decisive new material for the explanation of the effect is brought forward. The cooling of the kathode through escape of electrons is analogous to the cooling effect observed by Wehnelt with thermal electron escape and is in the sense of the explanation of the similarity of the two phenomena put forward by the author. The two current potential curves, both independent of the distance employed, commence under about 1200 volts, support Lilienfeld's statement which approximates to the assumption of a "kathode-fall" conditioned by positive ions. Referring to the alternative mentioned, it appears not to be proved that the third theoretical nearest possibility need no more be considered, *viz.* the setting in of the pure discharge with definite potential gradients at the surface. J. J. S.

1946. *Some Remarkable Peculiarities of Gold Layers.* **F. Gross.** (Zeits. f. Physik. 15. 1. pp. 40–45, 1923.)—In some cases when gold mirrors were deposited on glass or quartz by means of kathodic disintegration surprising formations were observed, which under the microscope have the appearance of approximately spherical bodies of various sizes on a uniform green gold ground. Photographs of the appearances are given, and they are shown as a collection of minute gold drops or blisters of ellipsoidal form. Some of the smaller unite to form larger ones, and with many the surface is turned in and has the appearance of a wheel with three spokes and jagged rim. The gold layer was nowhere torn, and the background of the wheels appears green in transmitted light and has no holes. All gold layers which had this special appearance were produce with a current of 10 milliamps. in intervals of time of from 20 to 40 minutes.

The phenomenon is more readily produced on a quartz surface than on glass. The thickness of the gold film was, on glass 43·2 $\mu\mu$, on quartz

63·3, 69·1, and 83·5 $\mu\mu$. The gold layers on quartz which had this structure exhibited a special photoelectric behaviour. J. J. S.

1947. *Lecture Demonstration Apparatus to Show the Effect of Dust Particles, Ions, and Electrons as Condensation Nuclei.* **C. Lakeman** and **R. Sissingh.** (Phys. Zeits. 24. pp. 235–236, June 1, 1923.)—A description is first given of a form of apparatus and working details for demonstrating the effect of condensation nuclei during the expansion of air saturated with water-vapour. Following this comes an account of a modified form of the Wilson apparatus for rendering visible the paths of ionising rays by photographic procedure. Shimizu later altered the apparatus so as to permit of 50 to 200 expansions per min., but in this form it is unsuitable for lecture demonstration purposes, and the present form of apparatus has been designed to this end. Two illustrations accompany the description. H. H. Ho.

1948. *The Ignition of Combustible Gases by Electric Sparks.* **J. D. Morgan.** (Phil. Mag. 45. pp. 968–975, May, 1923.)—The amount of heat energy that must be given to ignite a combustible gas varies very greatly with the conditions [see Abstract 1329 (1922)]. The heat energy required in the source to cause ignition is least when the heat is imparted instantaneously. For example, the spark produced by a single discharge from a condenser has a very high temperature and is of extremely short duration, and it is certain that to ignite a given gas mixture by such a spark a less amount of heat energy is required than that from an "inductance" spark. Patterson and Campbell (Proc. Phys. Soc. London, [Abstract 1231 (1919)] have shown that the energy required for ignition of a given gas mixture by a "capacity spark" may be a widely variable quantity. Their experiments have been repeated and extended by the present author with a view to comparing the results with the thermal hypothesis of ignition. The sparks were produced by discharge of a variable (air) condenser across a gap of variable width. In expressing the results the energy in the system prior to the occurrence of the spark is taken as a measure of spark energy, and this is correlated with spark-gap width. The most important variables involved are (1) the spark-length, (2) the configuration of the gas region adjacent to the spark, (3) the area of cooling surface presented by the electrodes. With certain assumptions a theoretical curve connecting gap width with quantity of heat is obtained which follows closely the general form of the experimental curve. The experiments in general afford important evidence in support of the thermal hypothesis of Jones, Morgan, and Wheeler. T. B.

1949. *On the Lichtenberg Figures.* **P. O. Pedersen.** (Danske Vidensk. Selskabs. Med. 4. 7 [36 pp.] 1922.)—Same paper as that referred to in Abstract 946 (1923) but in English. W. R. C.

1950. *The Arc-Light in Mixtures of Mercury-Vapour and other Gases.* **A. Günther-Schulze.** (Zeits. f. Physik, 15, 4 and 5. pp. 254–272, 1923.)—With the help of existing views on the mechanism of the current in the mercury arc-light some idea may be obtained of the phenomena to expect when the mercury arc-light is generated in a vessel of such size that the wall charges no longer disturb it, and when different foreign gases are introduced into such a vessel. In the present experiments a spherical glass vessel 40 cm. diameter is used. With this, three forms of arc-light can be distinguished: (*a*) A fine striated discharge of large cross-section and great tension consumption, (*b*) an unstriated discharge of mean width and tension consumption, (*c*) a thin extraordinarily clear skin of light of small tension consumption. These forms pass over from one to the other. The present paper deals with form (*b*). In pure mercury-vapour at low pressure the arc-light is to be seen at the kathode-fall and a clear zone round the anode completely without light; the loss of tension in the whole 25 cm. length is 3·4 volts. With increasing pressure the tension increases. When it exceeds 6 volts the arc-light from the anode begins to be lightened; with 4 mm. pressure and 11 volts loss of tension the illumination is extended up to the kathode. If foreign gases are added, the tension loss increases so much the more as (*a*) the more the heat conductivity of the foreign gas rises above that of the mercury-vapour, (*b*) the greater is the loss of energy of the electrons by collision with the molecules of the foreign gas. The gases are placed in the following order of loss of tension: Hg, Ar, CO_2, NH_3, N, H, O, SO_2. The greater the loss of energy of the electrons by collision with the molecules of the foreign gas, the greater is the tension loss at which the arc-light begins to illuminate. The increase of tension, owing to the addition of other gases, causes a rise in temperature in the vessel, and this in turn produces an increase in mercury-vapour pressure. A. E. G.

1951. *Inductively Coupled Low-Resistance Circuits.* **C. H. Lees.** (Roy. Soc., Proc. 103. pp. 70–83, April 3, 1923.)—A mathematical treatment is given for two circuits whose resistance is so small that damping may be neglected. This leads to expressions for the frequencies, amplitudes, and coupling which can be written down directly from the differential equations of the circuits; and also to a simple graphical solution of the whole problem. A. W.

1952. *Propagation of Hertzian Waves to Great Distances.* **G. Bigourdan.** (Comptes Rendus, 176. pp. 1099–1104, April 23, 1923.)—Analysis of the records at five observatories of the reception of time signals sent out from Paris leads to the conclusion that there may be perturbations of the order of 0·01 sec. in the time of propagation of the wireless waves. A. W.

1953. *Propagation of Electromagnetic Waves along an Iron Conductor.* **G. Laville.** (Comptes Rendus, 176. pp. 986–989, April 9, 1923.)—A method of study previously described [see Abstract 1448 (1923)] of the propagation of waves in a conductor consisting of strands of copper is applied to a similar conductor of iron. The resonance curves obtained are considerably more flattened at the points. A formula agreeing with the results is developed, and it is noted that the values calculated according to Kirchhoff's theory and from Kelvin's formula relative to current penetration do not agree with observed facts. A. B. C. L.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1954. *The Superficial Alteration of Glass Effected by High-Tension Currents.* **P. Woog.** (Comptes Rendus, 176. pp. 1797–1799, June 18, 1923.)—When the dielectric rigidity of an insulating hydrocarbon is measured in a glass vessel, a bubbling is often produced at the surface of the liquid. This agitation is due to the passage of a current of high tension, derived from the electrodes, and passing to the surface of the glass, this being relatively a conductor for the high voltage employed. An apparatus is now described for the study of this occurrence. For a sufficient voltage a discharge occurs with a characteristic crackling, and data are given for the special form of apparatus employed. Between the temperature limits of 11° and 100°, it is found when the oil level is maintained constant, that the voltage necessary for producing the discharge diminishes with heating. This property of glass appears to be caused by the efflorescence of the glass surface which liberates the bases by hydrolysis of the silicates, and the carbon dioxide of the air forms carbonate of soda, a body capable of considerable hydration. The authors have found by using oils of very different viscosities that the coefficient of internal friction plays no part, and that Wiedemann's law does not apply to these experiments. This variation at the surface of the glass permits the reception in the hydrocarbon of an amount of water less than 1/60000th. H. H. Ho.

1955. *Ionisation in Glass with High Field Intensities.* **A. Günther-Schulze.** (Phys. Zeits. 24. pp. 212–213, May 15, 1923.)—The results of H. H. Poole on the specific conductivity of glass can be explained by analogy with the behaviour of air, where i also increases exponentially with the field intensity. It can be assumed that in glass, as in air, free electrons are able to split off new electrons by collision, when the field intensity x is high enough, and that the number split off per cm. of path is proportional to x; the original free electrons are produced only at the kathode. The equations derived on these assumptions show that the conductivity, with constant field intensity, increases exponentially with the thickness of the plate. This requires experimental verification. H. N. A.

1956. *The Constitution of Dielectrics.* **O. M. Corbino.** (Accad. Lincei, Atti, 32. pp. 145–150, Feb. 18, 1923.)—Two theories of dielectrics are in the field. Larmor considers that the molecules contain permanently electric doublets, while Langevin assumes that the molecular polarisation is induced by the external field. On the assumption that the molecules are ellipsoids of revolution the author elaborates Langevin's idea mathematically. The conclusion is reached that the Born effect is only explainable on the hypothesis of permanent doublets. A. Wh.

1957. *The Temperature Dependence of the Change of the Dielectric Constant of the ZnSCu Phosphore through Illumination.* **J. Herweg.** (Zeits. f. Physik, 16. 1. pp. 23–28, 1923.)—Gudden and Pohl's work [see Abstract 85 (1921)] on the change of dielectric constant of the ZnSCu phosphore after activation is first reviewed, and then followed by a notice of Lenard's views on phosphorescence from the thermal standpoint. The present author now makes a determination of the dielectric constant of an activated ZnSCu phosphore at different temperatures. Experimental details are briefly given. It is found that the dielectric constant effect exhibits marked temperature dependence, increasing from very low temperatures to a maximum about 400° abs. and then falling rapidly. The higher the temperature, the more rapid is the final state of the increase reached, and the quicker is the decline of the dielectric constant after termination of the exposure. So far it has not been found practicable to confirm Lenard's views that at low temperatures the activated phosphore will store energy, but not emit it, owing to the thermal conditions not admitting of a return of electrons from sulphur to copper. H. H. Ho.

1958. *The Influence of an Electric Field on the Dielectric Constant of the ZnSCu Phosphore which has been Increased by Illumination.* **J. Herweg.** (Zeits. f. Physik, 16. 1. pp. 29–33, 1923.)—The increase of the dielectric constant of the ZnSCu phosphore by exposure to light of short wave-length has been explained by Gudden and Pohl [see Abstract 85 (1921)] by a displacement of electrons from the Cu to the S atoms, which on return produce the phosphorescence. The present paper seeks to find whether these mobile electrons are influenced by an external electric field, and the experimental arrangements employed for this purpose are now described. It has been found that the dielectric constant of an activated ZnSCu phosphore is diminished by an electric field. If the latter is constant, then polarisation ensues which can be avoided by an alternating field of 50 periods. The diminution in the dielectric constant grows linearly with the imposed field strength. An ultimate minimum field strength is necessary for producing the effect. An explanation is suggested for the phenomenon, *viz.* that electrons return in large numbers to the Cu atoms and are there held in Bohr orbits. A comparison is drawn between the measurements of F. Schmidt on the phosphorescent effect under the action of an electric field and the results now recorded. H. H. Ho.

1959. *Influence of Exposure to Light on the Dielectric Constant.* **R. Wilde.** (Zeits. f. Physik, 15. 6. pp. 350–357, 1923.)—On exposure to light the ZnSCu-α-phosphorus shows considerable increase of its dielectric constant. This effect is connected with the presence of the Cu-atom and seems related to the large displacement paths of the electrons within the small molecular groups or centres surrounding the atom. The rise in value of the dielectric constant of this substance when light falls upon it has its maximum at 140° C. At temperatures below about −100° it is not measurable nor at temperatures above 360°. The excitation of the effect with time runs parallel to the phosphorescence at all temperatures. The time rise of the effect is in the beginning of the illumination proportional to the light energy. J. J. S.

1960. *The Mass of the Electric Carrier in Metals.* **R. C. Tolman, S. Karrer,** and **E. W. Guernsey.** (Phys. Rev. 21. pp. 525–539, May, 1923. Nat. Acad. Sci., Proc. 9. pp. 166–169, May, 1923.)—Experiments were undertaken with the object of verifying the result obtained by Tolman and Stewart [Abstract 997 (1917)] which indicated that the carriers in metals have approximately the same ratio of mass to charge as an electron, and also with the hope of obtaining a more accurate value for the ratio m/e by using an entirely different method. An oscillating apparatus was used consisting of a copper cylinder 9⅛ in. long, 4 in. outside diameter, and 3 in. inside diameter, attached to a brass torsion rod in such a way that it could be oscillated about its axis with a frequency of about 20 cycles per second. Surrounding this copper cylinder was a coil containing about 60 miles of No. 38 copper wire which formed the secondary of a transformer and was connected to a vibration galvanometer through a specially designed three-stage amplifier. The tendency of the electrons in the oscillating copper cylinder to lag behind because of their inertia produces an e.m.f. whose value was obtained from the deflection of the vibration galvanometer tuned to the frequency of the mechanical oscillations. This galvanometer deflection was then compared with that produced by the known e.m.f. accompanying a transverse oscillation of the cylinder across the earth's magnetic field. The apparatus was mounted on a massive concrete pier 150 yards from the nearest electrical circuits, contained no magnetic materials, and was driven by compressed air. The axis of the oscillating cylinder was set parallel to the earth's magnetic field to reduce accidental effects. To obtain the mass of the carrier in copper 86 determinations of the ratio m/e were made, the average of which was $5 \cdot 2 \times 10^{-8}$. Since, however, the means of the first 42 determinations and of the last 44, obtained with the cylinder earthed only through the concrete pier and specially earthed, respectively, are 5·97 and 4·35, and since the corrections for zero amplitude were large, these preliminary results are not regarded as demonstrating a difference between the ratio m/e of the carrier in copper and of an electron in free space, $5 \cdot 66 \times 10^{-8}$. J. J. S.

1961. *The Thermoelectric Potential between Palladium Charged with Hydrogen and Pure Palladium.* **F. Heimburg.** (Phys. Zeits. 24. pp. 149–151, April 1, 1923.)—Measurements are made of the e.m.f. developed between palladium charged with hydrogen and the pure metal. A palladium wire is connected as the kathode of an electrolytic circuit and at either end welded to platinum leads, one end being insulated from the electrolytic current by sealing into a glass containing-tube. The amount of hydrogen occluded is evaluated from the change of resistance of the wire. A temperature difference is maintained at the two junctions and measured by Pt-Pd thermojunctions. The e.m.f. between the charged and uncharged portions is found to increase regularly with the difference of temperature and with the hydrogen content until an amount of 600 volumes is reached, and between this stage and 900 vols., it converges towards a limiting value. The e.m.f. amounts to 1·7 millivolts for a charge of 900 vols. of hydrogen and a temperature difference of 100° C., the current flowing through the heated junction from the uncharged to the charged palladium. It is found necessary to apply a correction for the gradual diffusion of the hydrogen from the charged to the uncharged portions of the wire. The results confirm the general conclusions previously reached by Knott. J. N. P.

1962. *Photoelectric Conductivity of Cerussite and Senarmontite.* **W. Heintze.** (Zeits. f. Physik, 15. 6. pp. 339–349, 1923.)—Further examples are given in confirmation of the fact established by Gudden and Pohl [Abstract 374 (1922)] that crystals with high refractive index exhibit photoelectric conductivity. Cerussite ($PbCO_3$) and senarmontite (Sb_2O_3) were examined. The former has a refractive index $n_\beta = 2 \cdot 0763$ for $\lambda = 589\ m\mu$, and the latter $n_{\text{white}} \sim 2 \cdot 36$, and they show the photoelectric conductivity which was expected. Diagrams are given of the spectral distribution of the photoelectric conductivity for the two materials over the range from 600 to 200 $m\mu$. The maximum for cerussite is at $\lambda \sim 280\ m\mu$ and for senarmontite at $\lambda \sim 313\ m\mu$. In the case of senarmontite the favourable position of the observation point allows the fundamentally important result to be established that the fall of the photoelectric conductivity in the region of the short waves already sets in with such waves as still go through the whole crystal thickness. The objection may then be put on one side that the fall is deceptive and due to small penetrative effect of the light and bad contacts. The photoelectric conductivities dependent upon the absorbed light energy remain considerably behind the quantum equivalent, a result which was to be predicted on account of the strong cloudiness of the crystals. J. J. S.

1963. *Photoelectric Conduction and Chemical Union.* **B. Gudden** and **R. Pohl.** (Zeits. f. Physik, 16. 1. pp. 42–45, 1923.)—Fajans has recently sought to explain a large number of physico-chemical facts from a general standpoint, and he ascribes the particular behaviour of certain inorganic compounds respecting colour, lattice-energy, volatility, solubility, etc., to the distortion of the electronic frame of the anions by the action of the kations in the lattice. The compounds specified by Fajans are those which have been recognised by the present authors as carriers of photoelectrical conduction, *e.g.* the majority of sulphides and oxides, the halides of many heavy metals, some carbonates, and certain homopolar bodies such as the diamond, sulphur, red selenium, and iodine. Further it has been found that in many of these substances the effect is essentially determined by the kation. Lists of bodies are given in the paper showing the above parallelism between Fajans' results and the photoelectrical observations. The authors incline to the opinion that the transition from pure hetero-polar to homo-polar union arises in an increasing phase relationship of the electronic rotations in all the lattice-forming atoms. Such a phase-like synchronism of the electrons affords not only knowledge concerning electronic conduction and its modification by structural disturbances, but conditions, perhaps, the magnitude of the terms in the dispersion formula without necessitating the assumption of a specially large displacement. H. H. Ho.

1964. *The Electrical Conductivity of Molybdenite.* **A. T. Waterman.** (Phys. Rev. 21. pp. 540–549, May, 1923.)—As the mineral molybdenite (MoS_2) does not obey Ohm's law the effects of temperature and applied e.m.f. on the current transmitted were examined. Measurements of the currents through narrow flat strips cut perpendicular to the crystallographic *c*-axis gave results for the range from 0° to about 200° C. in agreement with the equation: $i = KV^b e^{-k/T}$ where i = current, V = applied e.m.f., T = abs. temperature, and b, k, and K are constants. For the mineral in the ordinary state k is about 3000 and b generally about 1·6. When the voltage is increased to a critical value breakdown occurs due to the electric heating. An expression is derived for the breakdown temperature which is shown to increase as k diminishes. Above 200° irregularities appear. After heating to 400° or above, or after current heating beyond the breakdown point, the conductivity at ordinary temperatures is usually permanently improved and k is decreased. By the use of proper current cycles a strip may be transformed by stages from a very poor conductor into a reasonably good conductor obeying Ohm's law. At the same time k diminishes and the breakdown temperature rises until the break disappears at the limiting value of k predicted by the equation; also the photoelectric sensitivity and dielectric polarisation disappear. The conductivity is also increased by a high potential discharge. This remarkable permanent change of conducting state may indicate a corresponding change of structure as suggested for selenium. If the constant h is interpreted as being equal to ϕ/R, where ϕ is the energy required to change a bound to a free electron and R is the gas constant, then ϕ is computed to vary from 0·26 volt for MoS_2 in its normal state to 0·13 for the conducting state. This may be of interest in connection with the electron theory of conductivity. J. J. S.

1965. *An Improvement of the Mirror Galvanometer.* **W. Möbius.** (Phys. Zeits. 24. pp. 217–221, May 15, 1923.)—For bringing about a refinement of the mirror reading a Fresnel double mirror is used instead of the ordinary galvanometer mirror and the interference fringes read by means of a micrometer. The utility of the instrument is thereby improved enormously. The paper contains a detailed description of the modified instrument and its working. H. H. Ho.

1966. *A New Galvanometer.* **R. Mechau.** (Phys. Zeits. 24. pp. 242–245, June 1, 1923.)—This galvanometer has resulted from the demand for a very sensitive instrument occasioned by a previous discovery of a new type of thermoelement specially suitable for ultra-red radiation [see Abstracts 266 and 921 (1921)]. The principle involved is the pendulum-like oscillation of a thin metallic frame in a magnetic field. The metal is almost non-magnetic and the magnetic field is produced by weak permanent magnets capable of such arrangements as are convenient for producing the required sensitiveness. The paper gives a very complete description of the instrument with 5 illustrative figures. All galvanometer requirements are claimed to be fulfilled by this instrument. H. H. Ho.

1967. *Einthoven String Galvanometer.* **A. Pochettino.** (Accad. Sci. Torino, Atti, 57. 2. pp. 43–52, 1921–1922.)—The discussion of the theory of the string galvanometer has been in general of too mathematical a character and has not considered many of the cases commonly occurring in practice. The author in this paper gives a short and simple presentation of the theory, taking account of some practical cases which are specially important. J. J. S.

1968. *A New Form of String Electrometer.* **C. W. Lutz.** (Phys. Zeits. 24. pp. 166–170, April 15, 1923.)—The string electrometer has been described previously by the author [see Abstract 123 (1913)]. The present paper deals with modification which adds greatly to its general utility. A photograph, and also a diagram, illustrating the instrument are given. A. E. G.

1969. *Measurement of very High Peak Potentials of any Frequency.* **A. Hund.** (Jahrb. d. drahtl. Tele. 21. pp. 312–315, May, 1923.)—The method described consists essentially of introducing a fraction of the high potential to be measured into the anode circuit of a triode valve and varying the grid potential till the anode current vanishes. A known anode potential serves to calibrate the arrangement. The fraction of the high potential is obtained from a static potentiometer consisting of four equal and parallel plates arranged with their centres in line. The high potential is applied to the two outer plates and the fractional potential obtained from the two inner ones. A. W.

1970. *Thermoelement for Measurement of Radiation.* **R. Hase.** (Zeits. f. Physik, 15. 1. pp. 52–53, 1923.)—There are various metallic alloys which are capable of developing high thermo-e.m.f. and are thus suitable for use in thermoelements, but their physical properties do not permit them to be made into wires and thus their use in thermoelectric junctions is made difficult. A thermoelement is described in which such alloys can be used in the form of short brittle rods a few mm. in length. When such a junction is exposed to a source of radiation a considerable e.m.f. is developed in a short time and the arrangement can be used to measure the radiation falling upon the junction.

J. J. S.

1971. *A Braun Tube for Secondary Kathode Rays.* **V. Engelhardt.** (Phys. Zeits. 24. pp. 239–242, June 1, 1923. From the Reichsanstalt.)—The paper contains the description of a Braun tube with glow kathode and secondary kathode from which latter the secondary kathode radiation can be used for oscillographic purposes. The arrangement of the electrodes, etc., permits of two beams being received on the screen. It is proved by a variety of measurements that the latter is affected by the hard rays from the primary and the soft ones from the secondary emission.

H. H. Ho

1972. *An Electromagnetic Inductor.* **L. F. Richardson.** (Phys. Soc., Proc. 35. p. 213, June, 1923.)—Description of an experimental apparatus for teaching purposes. W. R. C.

1973. *A Precise Method of Measuring Small E.M.F.'s and the Change in the Thermoelectric Power of Tin at the Melting-Point.* **T. R. Harrison** and **P. D. Foote.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 389–398, May, 1923.)—A potentiometer device designed for the measurement of e.m.f.'s. with a precision of 0·1 microvolt, and embodying special devices for the elimination of parasitic e.m.f.'s is described. The instrument was employed to determine the thermoelectric power of a platinum-10 %-rhodium versus tin thermocouple in the vicinity of the melting-point of tin. The tin used was of 99·988 % purity. The results obtained indicate that the difference of the thermoelectric powers of liquid and solid tin at the melting-point (231·9° C.) amounts to 1·2 ± 0·2 microvolt per degree C., the liquid being at the higher potential. The existence of a *discontinuous* change in the thermoelectric power of tin at the melting-point was definitely established photographically [see Abstract 1394 (1911)]. J. S. G. T.

ALTERNATING CURRENTS AND MAGNETISM.

1974. *The Modern Theory of Magnetism.* **L. Donati.** (Elettrotecnica, 10. pp. 325–327, May 25, 1923.)—The theory of magnetism is explained according to the modern views on electrons. The known differences between magnetic and electric circuits with regard to mechanical work are in this manner clearly explained, though some points still remain in darkness. E. B.

1975. *Paramagnetism and the Theory of Quanta.* **P. S. Epstein.** (Science, 57. pp. 532–533, May 4, 1923.)—The author refers to Cabrera's paper on the magnetism of salts of metals belonging to the iron group [see Abstract 116 (1923)], and gives an interpretation of Cabrera's results which seems strongly to support the quantum theory of magnetism. The magnetic moment *m* of the atom or ion is expressed, by means of the theory of electrons, in terms of G, the principal moment of momentum of the atom. By the theory of quanta, the values admissible for G are multiples of a certain constant, so that *m* may be expressed by means of the equation: $m = jm_0$, where m_0 is called the Bohr magneton, and *j* the internal quantic number of the atom. The empirical Weiss magneton is almost exactly a fifth of the Bohr magneton. Taking the Langevin formula connecting the susceptibility χ and the atomic magnetic moment *n*, and using Pauli's correction, the author obtains from Cabrera's results a table of corrected valves of *m* for the ions of the iron group. Calculated and observed values of χ are also tabulated. The values for *j* and m_1 (Bohr magneton) and the calculated and observed values of χ do not agree in the cases of Fe^{++} and Ni^{++}; the case of Fe^{++} is without significance. The other paramagnetic salts show excellent agreement with the quantum theory. The author suggests another method of checking the results, and directs the attention of investigators to the ions Fe^{++} and Ni^{++}. G. E. A.

1976. *On Paramagnetism and the Structure of the Atom.* **A. Dauvillier.** (Comptes Rendus, 176. pp. 1802–1805, June 18, 1923.)—In a recent paper Cabrera [see Abstract 971 (1923)] has shown that the magnetic moments of various elements ranging from titanium to copper when expressed in Weiss magnetons vary in a very regular way as a function of a certain whole member, passing through a maximum in the middle of the period and vanishing at its extremities. Cabrera interprets this result by assuming that the electronic layer of the element is complete with 8 electrons, and that the moment is due to the peripheral electrons alone. The present author takes another view and assumes on the contrary that paramagnetism is due to two distinct causes working sometimes singly and at other times simultaneously, *viz.* the superficial and the internal electrons. The data used is from X-ray spectra, ionisation potentials, and limits of optical series. Section I deals with the number of electrons upon the layers of the ions scandium to copper and Section II considers paramagnetism in the rare earths. The paper is throughout one of detailed physical reasoning and should be consulted in its entirety. H. H. Ho.

1977. *Magnetisation, Rotation, and Atomic Structure.* **S. J. Barnett.** (Phys. Zeits. 24. p. 14, Jan. 1, 1923.)—Braunbek's theory of rotation by magnetisation [Abstract 22 (1923)] is identical with that published by O. W. Richardson in 1908 and referred to by Stewart [Abstract 412 (1918)] and by Chattock and Bates [Abstract 972 (1923)]; see also Barnett [Abstract 1761 (1915)]. T. H. P.

1978. *A New Material for Permanent Magnets.* **E. Gumlich.** (Zeits. f. Physik, 14. 3 and 4. pp. 241–252, 1923.)—This article gives further particulars about the new type of steel, which has been found by the Reichsanstalt to give better results when used for magnets. Weiss and Preuss discovered that an improvement was made by adding cobalt to alloys of iron and manganese: the author shows that an improvement results from a further addition of chromium. The article contains the results of tests on various alloys, hardened at different temperatures. The Krupp firm supplied the samples for the tests, and is undertaking the manufacture of the improved alloy, but at the moment there are likely to be difficulties owing to the high price of cobalt. W. H. S.

1979. *The Polarisation of Colloidal Iron in Magnetic Fields.* **O. M. Corbino.** (Accad. Lincei, Atti, 32. pp. 59–64, Jan. 21, 1923.)—A mathematical discussion of the effects to be expected when a solution of colloidal iron is exposed to varying magnetic fields. In an alternating field the polarisation changes phase with respect to the field continuously and hence it is shown that in a rotating field, the direction of polarisation will also be rotating but not synchronous. The effects are due to a mechanical drag or viscosity action, and it should be possible to deduce from them the angular momentum of the particles. Since a similar molecular action is observed by Lertes for electrostatic fields in dielectrics, it should be possible to determine the angular momentum of the electric doublets in such cases. A. Wh.

1980. *Permeability of an Artificial Magnetic Medium.* **A. Goldhammer.** (Phys. Zeits. 24. pp. 111–112, March 1, 1923.)—A reply to Maurer's criticism [see Abstract 2326 (1922)]. The increase in the permeability of the space containing the steel balls corresponds to an actual increase in the permeability of the steel of which the balls are made. G. E. A.

1981. *Permeability of an Artificial Magnetic Medium.* **H. Maurer.** (Phys. Zeits. 24. p. 217, May 15, 1923.)—The author agrees with Goldhammer that the calculation is based on uncertain data [see preceding Abstract]. G. E. A.

1982. *Effect of Tension on Susceptibility of Magnetite.* **E. Wilson.** (Roy. Soc., Proc. 103. pp. 185–189, April 3, 1923.)—Tests on specimens of magnetite from various localities, subjected to tensile stress up to 130 kgm. per sq. cm. show that in a given field the susceptibility at first increases with the stress, then decreases and exhibits a reversal point as in iron. The magnetic force at which the percentage increase in permeability has a maximum value is less than the force for which maximum susceptibility occurs [see also Abstract 2458 (1922)]. G. E. A.

1983. *Effect of Torsion on the Magnetic Properties of Iron and Steel.* **H. Krüzner.** (Archiv f. Elektrot. 12. pp. 234–248, May 28, 1923.)—The material tested consisted of wires 4·5 mm. diam. and 32 cm. long, which were annealed, then tested magnetically by a yoke ballistic method, next twisted by a certain amount, again tested magnetically, and so on until the wire gave way. The magnestising current was regulated by Sahulka's liquid rheostat in which, by the rotation of two electrodes between two fixed electrodes in copper sulphate, the current may be varied in the cyclic manner required for a hysteresis test. Wires of soft iron (commercial) and tool steel were investigated and the results given in tables and curves. With increase of torsion of soft iron, there is diminution of $B_{max.}$ and of $B_{rem.}$ expressed as a percentage of $B_{max.}$; but H_c and hysteresis are both increased. With increased torsion applied in cycles, the effect was of the same nature, except that the hysteresis first diminished and then increased to a higher value than the initial one. The magnetic changes of the steel wire under similar mechanical treatment resembled those of the soft iron. G. E. A.

1984. *Magnetic Testing of Steels under Traction. Elastic Limits.* **L. Fraichet.** (Comptes Rendus, 176. pp. 1795–1796, June 18, 1923.)—The bar for testing is arranged as the core of a coil with two windings, the one a primary connected to an accumulator, and the other a secondary connected to an ordinary galvanometer with photographic recorder. The variation of magnetisation during traction was carried out for 78 bars of 26 different varieties of steel. With the same tension and the same magnetising force, the same variety of metal always gives the same magnetisation diagram which can thus serve for its identification. The diagram indicates a permanent molecular deformation for a relatively low load which is only dependent on the nature and treatment of the metal. The ratio of the true elastic limit to the limit of proportionality is 0·7 to 0·95 for ordinary annealed steels; 0·5 to 0·65 for ordinary steels tempered with oil or water. For ordinary steels tempered without annealing and for cast steels which have not a defined limit of proportionality, the ratio between the true elastic limit and the breaking stress varies from 0·25 to 0·45, the low value explaining the fragility of such steels. H. H. Ho.

1985. *Demagnetisation of Iron by Electromagnetic Oscillations.* **S. K. Mitra.** (Comptes Rendus, 176. pp. 1214–1217, April 30, 1923.)—The demagnetisation of an iron wire by an alternating current in an enclosing solenoid, first observed by Henry, was utilised by Rutherford and Marconi to detect oscillations of high frequency. Marconi found that the oscillations increased the magnetisation, when the iron is in a field of increasing amplitude, and *vice versa*; also the hysteresis for very slow variation of the field is diminished if a field of high frequency is superposed. These observations were verified by Wilson and Eccles, the oscillating currents employed being highly damped. The author obtains an oscillating current from a circuit containing two French valves in parallel, and investigates first the residual magnetism of an iron wire, using a calibrated magnetometer to measure the decrease in magnetisation I_1–I_2. The frequency is measured by a wave-meter, except for very low frequencies for which a small alternator was employed. The effective intensity of the a.c. used was 0·3 ampere. I_1–I_2 varies from 516 at zero frequency to 32·8 at frequency 500,000, for an annealed iron wire. When the wire is hardened, the demagnetisation is a smaller fraction of the residual magnetism. Another series of experiments was made on the effect of the oscillations on hysteresis, and it was observed that whilst the extreme points of the cycle remain unchanged, the area of the cycle is much reduced when a high-frequency field is superposed on the magnetising field. G. E. A.

1986. *Magnetisation of Nickel.* **H. Pécheux.** (Comptes Rendus, 176. pp. 1134–1137, April 23, 1923.)—Investigation of the effects of quenching and annealing on the magnetic properties of commercial nickel. Three cylindrical bars of the same size and of given chemical composition were tested by means of Carpentier's torsion permeameter, and values are found for the magnetising field corresponding to maximum permeability, H_c, B_{rem}, and B for max. field 24·7 c.g.s. The bars contained respectively, 1·43, 1·38, and 1·68 per cent. of iron, but no copper or cobalt. When tested previously to their heat treatment, the bars exhibited magnetic differences. After quenching from 400° in water a slight increase in H_c and decrease in $B_{rem.}$ were noted. On being heated at 800° for half an hour and then slowly cooled, an increase in μ and decrease in H_c were observed. The Brinell hardness numbers for the bars in their final states are also given. In the Steinmetz formula: $W = aB^x$, x has the value 1·503 and a has the respective values 0·068, 0·073, and 0·055 for the three bars. [See also Abstract 288 (1908).] **Errata** (*ibid.* p. 1580, May 28, 1923). G. E. A.

1987. *Anomalous Initial Magnetic Permeability in Nickel and Steel Wires, with High-Frequency Fields.* **B. Wwedensky** and **K. Theodortschik.** (Phys. Zeits. 24. pp. 216–217, May 15, 1923.)—The authors have shown that the permeability of iron wires, for wave-lengths from $\lambda = 300$ m. to $\lambda = 54$ m., is not constant, but varies in a complicated manner [Abstract 763 (1923)]. Further observations prove that Ni and steel show the same anomaly. The curves obtained indicate a specially complicated relation for quenched steel. Although the maximum of the Ni curve is near $\lambda = 88$ m., while for iron it is near 100 m., there is an unexpected similarity between the two curves. Ni shows clearly the iron maximum at 100 m., and two other maxima near 88 m. and 180 m. The phenomena must be due to selective absorption, or magnetic conductivity, which is being investigated. For the present no correction for eddy currents is made. H. N. A.

1988. *Paramagnetic Sulphates at Low Temperatures.* **L. C. Jackson** and **H. K. Onnes.** (Roy. Soc., Proc. 102. pp. 678–679, March 1, 1923.)—It has been shown that while all paramagnetic substances obey the Curie-Weiss law: $\chi(T + \Delta) = \text{constant}$, down to about 80° K., some show deviations from the law at lower temperatures. Further, in a series of substances of similar constitution, the constant Δ was found to be smaller, the greater the amount of water of crystallisation present. Later experiments on the anhydrous sulphates, heptahydrated sulphates, and ammonium double sulphates of cobalt and nickel show that the phenomena are more complex than was indicated by the earlier work. Maxima and minima of susceptibility may occur in the region of liquid hydrogen (14°–20° K.), besides other deviations, and the dependence of the value of Δ on the amount of water of crystallisation is not a simple one. These later results receive no explanation on any of the previous theories except that of Foëx. G. E. A.

1989. *Paramagnetism of Crystals at Low Temperatures.* **L. C. Jackson** and **H. K. Onnes.** (Roy. Soc., Proc. 102. pp. 680–681, March 1, 1923.)—An investigation of the principal susceptibilities of monoclinic cobalt ammonium sulphate and rhombic nickel sulphate heptahydrate at temperatures down to 14° K. (M.P. of hydrogen). For the first substance, the Curie-Weiss law is followed down to about 80° K. for each of the three principal susceptibilities; the constant C in $\chi(T + \Delta) = C$ is the same in the three cases, and the greater the value of χ, the smaller is Δ. At lower temperatures, χ increases more rapidly with temperature than is given by the above law; the deviations are not the same for the three cases. Nickel sulphate shows similar phenomena. Further experiments indicate that the measurement of the principal susceptibilities as functions of the temperature may serve to determine the structure of paramagnetic crystals, at least as concerns the positions of the paramagnetic atoms. G. E. A.

1990. *The Utility of Permanent Magnets.*. **J. Würschmidt.** (Zeits. Instrumentenk. 43. pp. 121–126, April, 1923.)—The serviceability of a permanent magnet may be assessed either by the apparent remanence or by the product of the true remanence and coercitive force. The apparent remanence obtained for a definite form of magnet gives, however, no standard data for another form, and for this purpose not only must information be to hand of the coercitive force and true remanence, but also of the requisite part of the magnetisation curve of the material under consideration. Further the demagnetisation factor must be obtained, and this is only as yet calculable for ellipsoidal and circular-cylindrical bars. For straight bars as for horseshoe magnets experimental measurements are necessary. The reversible permeability is also of influence on the lifting power of a permanent magnet. H. H. Ho.

1991. *Magnetic Variation and Solar Activity.* **C. E. Brazier.** (Comptes Rendus, 176. pp. 1821–1824, June 18, 1923.)—The magnetic agitation is expressed by the numbers 0 to 7 and a long series of observations at Parc St. Maur and Val Joyeux correlated with the solar activity for the period 1884–1917, being three periods. The maximum and minimum do not occur at exactly the same time in the three periods considered, and the correlation coefficient between the annual mean value of the magnetic and solar activities (the latter expressed as Wolfe's numbers) is only 0·33. This leads to a considerable doubt if the connection is direct and simple and emphasises that the position of the earth in its orbit is also a factor to be considered. A. Wh.

1992. *Proposed Magnetic and Allied Observations during Solar Eclipse of September* 10, 1923. **L. A. Bauer** and **J. A. Fleming.** (Terrest. Magn. 28. pp. 29–32, March–June, 1923.)—Details are given of the plans made to secure accurate magnetic, electric and meteorological observations at a number of stations within and near the belt of totality before, during, and after the eclipse. G. E. A.

1993. *The Earth's Magnetic Potential.* **F. Dyson** and **H. Furner.** (Roy. Astron. Soc. M.N. Geophys. Suppt. 1. No. 3. pp. 76–88, May, 1923.)—From recent magnetic observations the values of the easterly, northerly, and vertical components of the earth's magnetic force for the intersections of 10° parallels and meridians are calculated and tabulated. The results were analysed in a series of spherical harmonics and the values of the magnetic potential found in order to test Bauer's conclusion [Abstract 698 (1921)] as to upward vertical currents around the poles and downward currents in the tropics. Though there is some evidence for Bauer's results, the authors conclude that the existence of vertical electric currents is not indicated with any great certainty. G. E. A.

1994. *Analysis of the Earth's Magnetic Field for* 1922. *No.* 1. **L. A. Bauer.** (Terrest. Magn. 28. pp. 1–28, March-June, 1923.)—From a new analysis of the earth's magnetic field for 1922 made as free as possible without assumptions as to the composing systems and restricted to the region of the earth (86 per cent.) from 60° N. to 60° S. the author concludes that for a satisfactory representation of the observed data it is necessary to recognise the existence of an internal magnetic system I, an external system E, and a non-potential system N, or of three equivalent systems, X, Y, Z. The system I constitutes about 94 per cent. of the total field, and E and N each about half of the balance of 6 per cent. It is shown that the magnetic secular variation system is as complex as the earth's total magnetic field existing at any one time, and that in addition to changes in the direction of magnetisation with the lapse of time there is also a change in the average equivalent intensity of magnetisation. The latter quantity has been steadily diminishing during the past 80 years at the average annual rate of about 1/1500 part. AUTHOR.

1995. *The Criterion of Magnetic Disturbances.* **C. Chree.** (Terrest. Magn. 28. pp. 33–40, March–June, 1923.)—The question is considered whether a better method than the present one of indicating the magnitude of the disturbances observed at magnetic observatories by means of an international "character" figure could be devised. The author concludes that the best policy, at least for a time, would be to continue the existing scheme at all stations, and to get a limited number of representative well-equipped stations to obtain, in addition, results from whatever new scheme is decided upon. G. E. A.

1996. *The Magnetic Characterisation of Days.* **L. A. Bauer.** (Terrest. Magn. 28. pp. 41–44, March–June, 1923.)—On the same question as the preceding abstract. Besides the use of magnetic "character" numbers, a measure proposed by the author was to evaluate ϵHR_H, where ϵ is a constant, H the horizontal component, and R_H the range of H at the station. The author is inclined to agree with Chree's suggestion. G. E. A.

1997. *Records of the Survey of India.* (Survey of India, Records. 16. [140 pp.] 1920–1921.)—Includes magnetic survey, report on Mount Everest survey, etc. W. R. C.

1998. *Magnetic Measurements in Normandy.* **C. E. Brazier.** (Comptes Rendus, 176. pp. 958–960, April 3, 1923.)

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1999. *Adsorption of Gases by Solids: Thickness of the Adsorbed Layer.* **M. H. Evans** and **H. J. George.** (Roy. Soc., Proc. 103. pp. 190–193, April 3, 1923.)—According to Langmuir [Abstract 1279 (1918)], when gases are adsorbed at solid surfaces the thickness of the adsorbed layer of gas is never greater than the diameter of a molecule. This author concludes, therefore, that the forces which bind the molecules to the surface cannot extend to a distance from the surface greater than this diameter, and employs this conclusion as the basis for his theory of the mechanism of chemical reactions at solid surfaces [Abstract 2024 (1922)].

As Langmuir's experiments were carried out at low pressures and as the results of other investigators appear to indicate that the degree of adsorption of many gases is greatly in excess of that supposed by Langmuir, the author has made measurements of the adsorption of carbon dioxide on glass wool. The results show for the thickness of the adsorbed gas layer values from 5·14 to 5·94 times the diameter of the carbon dioxide molecule, the adsorbed gas being assumed to have the density of the liquid. For the equilibrium pressure of the carbon dioxide values ranging from 121·12 to 121·68 mm. are obtained. From Mülfarth's data [Abstract 162 (1901)] for the adsorption of various gases by powdered glass at 0° and at the equilibrium pressure 121·46 mm., the thicknesses of the adsorbed layers, in terms of the molecular diameters, are calculated to be: sulphur dioxide, 32·1; ammonia, 39·9; nitrous oxide, 4·5; and acetylene, 3·5. T. H. P.

2000. *Adsorption of Carbon Monoxide and Hydrogen by Platinised Asbestos.* **F. H. Pollard.** (J. Phys. Chem. 27. pp. 356–375, April, 1923.)—Determination of the adsorption isotherms of hydrogen, carbon monoxide, and mixtures thereof by platinised asbestos at 0° and at pressures ranging from 0 to 1 atmos. is rendered difficult by the considerable diminution in the adsorptive power of the platinum caused by impurities entrained from greased stopcocks. The process of adsorption is a reversible one providing that sufficient time is allowed to elapse for the establishment of equilibrium; the adsorbed gas may be removed completely from the metal by protracted pumping-out at 0°. The results obtained fail to support the view that the gases tried form definite solid compounds with platinum at 0°.

When the contamination of the adsorbent was reduced as far as possible, the platinised asbestos used adsorbed, at 0° and atmospheric pressure, 200 vols. of hydrogen or 300 vols. of carbon monoxide, these volumes being expressed in terms of the volume of platinum present. The addition of carbon monoxide in small proportions to the system hydrogen and platinised asbestos completely displaces the adsorbed hydrogen; this evidence supports Bancroft's theory of catalytic poisoning and accounts for the poisoning effect of carbon monoxide in certain catalytic hydrogenations. T. H. P.

2001. *Mercury Cleansing Apparatus.* **A. E. Dixon** and **J. L. McKee.** (Chem. Soc., J. 123. pp. 895–897, April, 1923.)—A convenient apparatus for cleaning mercury by spraying is described. T. H. P.

2002. *The Superficial Properties of Mercury Deduced from Voltaic Measurements.* **E. Perucca.** (Accad. Sci. Torino, Atti, 59. 2. pp. 53–62, 1921–1922.)—Using apparatus similar to that previously employed [Abstract 1376 (1922)] the author has reached the following results: (1) The voltaic properties of fresh mercury surfaces prepared *in vacuo* are constantly reproducible within 0·005 volt and vary very little in consequence of the introduction with the vacuum of sensible quantities of air, air deprived of oxygen, H_2, CO_2, well dried. (2) The fresh surface of Hg is the seat of a process of molecular or atomic adjustment so much the more rapid as the pressure of the superincumbent gas is less. There results from this a noteworthy support of the theory of Langmuir on the constitution of the surface layer of liquids. (3) Observed experimental facts prove the strict interdependence of the surface tension and the voltaic properties of a surface. J. J. S.

2003. *The Analysis of Bubbles in Glass.* **Research Staff of the General Electric Co., London.** (Phys. Soc., Proc. 35. pp. 197–198, June 15, 1923.)—In order to distinguish bubbles generated by chemical action in glass from those introduced by mechanical processes spectroscopic tests are made for the presence of nitrogen. In order to liberate the gas from the bubbles a specimen of the glass is placed in one limb of a quartz **U**-tube and mercury in the other, and the glass is heated and then disintegrated by sudden cooling, the tube being plunged into cold water at the same time that the mercury is thrown on to the glass. AUTHORS.

2004. *Dialysis of Small Volumes of Liquid: The Lily-Pad Dialyser.* **R. W. Wood.** (J. Phys. Chem. 27. pp. 565–566, June, 1923.)—A method is described of preparing a collodion cell in which as little as a single drop can be dialysed. T. M. L.

2005. *Colloid Chemistry.* **W. D. Bancroft.** (Am. I.E.E., J. 42. pp. 367–371, April, 1923.)—An address of a general character to electrical engineers. W. R. C.

2006. *Anomalous Osmosis with Colloidal Membranes. Part II. The Effect of Pore Diameter.* **F. E. Bartell** and **D. C. Carpenter.** (J. Phys. Chem. 27. pp. 252–269, March, 1923.)—The previous work [Abstract 1246 (1923)] on osmosis with colloidal membranes was continued. Membranes of three different degrees of permeability were prepared and their permeability determined. The osmose values in millimetres were observed at the end of 2-hour and 12-hour periods. The salts employed were: KCl, $CaCl_2$, $AlCl_3$, K_2SO_4, $K_3Fe(CN)_6$, and sucrose, in concentrations ranging from 0·001 M to 0·5 M. The results showed that the least porous membrane, with a pore diameter of about 0·7 microns, for potassium salts, gave the following anion order: $SO_4'' > Cl' > Fe\,C_6H_6'''$ in the case of dilute solutions. For concentrated solutions the order for the least porous membrane was $Cl' > SO_4'' > Fe, C_6H_6'''$.

For medium porous membranes, with a pore diameter of 0·93 microns, the anion order for rate of diffusion of potassium salts from dilute solutions was $SO_4'' > Cl'' > FeC_6N_6'''$, and with concentrated solutions was $Cl' > SO_4'' > FeC_6H_6'''$. For very permeable membranes, with a pore diameter of about 1·6 microns, the anion order of diffusion for potassium salts is $Cl' > SO_4'' > FeC_6N_6$, for both dilute and concentrated solutions.

The paper clearly shows the fact that the pore diameter of an osmotic membrane is a highly important factor in determining the exact nature of osmosis.

Part III. The Effect of Stirring Solutions.—Measurements of the rate of osmosis were made in a specially designed rocking cell. The same solutions were used as in the previous series of experiments. The results showed that stirring increased the rate of passage of all electrolytes through the membrane at all concentrations. The relative increase in rate of diffusion due to stirring was greatest in dilute solutions. With potassium salts, the anion order was $Cl' > SO_4'' > FeC_6H_6''''$ at all concentrations, which is the same as for unstirred solutions. F. J. B.

2007. *Preparation and Properties of Pure Graphite.* **M. Pirani** and **W. Fehse.** (Zeits. Elektrochem. 29. pp. 168–174, April 1, 1923.)—Threads of artificial silk are carbonised for 20 hours at 500° max., yielding filaments, up to 0·01 mm. thick, which on further heating in hydrogen up to 3000° finally contain only 0·07 % of ash. Total absence of ash cannot be obtained, since the carbon furnaces yield vapours of metallic oxides, and above 2500° the filaments become very brittle, so that ash contents of 0·3 % had to be tolerated. These filaments are further heated in carbon compounds, gaseous (carbon tetrachloride at 15 mm. pressure best) or liquid; graphitic carbon is deposited on the core filament, especially between 1500 and 2000°, so that the filament, before further heating in CO to 3500°, has a diameter of about 0·3 mm. The final filament consists of a core, which can be bent in the cold like lead, surrounded by a graphitic crust and a brownish film, both of which can be wiped off; the average ash percentage is 0·1. The graphite gives graphitic acid and swells when treated with fuming nitric acid. Mechanical properties and Röntgen analysis suggest that the graphite crystals are cylindrical to the core and that the elasticity of the filament resembles that of a strip of paper wound to a spiral. The elasticity depends upon the mode of preparation; it is absent in specimens prepared from hexachlorobenzene. The density, varying much in the uncalcined specimen, is finally about 2·12. There seemed to be particles of density 2·26. The electric conductivity increases as the graphite becomes denser and more felted, and the absolute values fluctuate much owing to varying orientation and crystalline adhesion. The specific resistance of the prepared filament (before calcination) is at 2000° only ¼ of the cold resistance and the temperature coefficient is strongly negative; above 3000° the temperature coefficient is positive. The lowest specific resistance observed was 0·5 ohm per $mm.^2$ per m., and the highest temperature coefficient 0·1 per cent. per deg. C.; these figures would agree with those of Roberts [Abstract 117 (1913)] for Ceylon graphite, and the artificial graphite thus strongly resembles natural graphite. Some thermal conductivity measurements were made after Ingenhous, filaments of graphite, copper, aluminium, nickel being coated with Japan wax and heated; the graphite seemed to conduct heat better than copper. Thermoelectrically the graphite stood (like carbon) between platinum and palladium, the current flowing in the hot junction from platinum to graphite. H. B.

2008. *The Non-Validity of Photoelectric Laws in Photochemical Phenomena.* **J. Plotnikow.** (Zeits. wiss. Phot. 22. pp. 110–116, Feb., 1923.)—This paper forms a continuation to previous photochemical studies [see Abstract 1743 (1922)] and is a theoretical discussion of results of various authors which show that under certain conditions the photoelectric formula has to be replaced by a more complicated photochemical formula. A. E. G.

2009. *The Photochemistry of Unstable Substances.* **E. J. Bowen.** (Chem. Soc., J. 123. pp. 1199–1206, May, 1923.)—Among the various attempts to apply the quantum theory to the problems of chemical reactivity is the so-called law of the photochemical equivalence, first obtained by Einstein [see Abstract 1046 (1912)], which is generally accepted as forming a basis for the consideration of photochemical reactions. The number of molecules reacting is equated to the number of quanta in the light absorbed by the system. This law was shown by Einstein to be the necessary average (and approximate) result from the radiation laws in the case of a photochemical "stationary state," having properties of a rather hypothetical character. The view now taken is to regard the law as founded on the quantum absorption of radiant energy, and therefore as equally applicable to "irreversible" photochemical reactions. In the present investigation it is found that the photochemical decomposition of carbon tetrachloride solutions of chlorine peroxide, and of chlorine monoxide under the influence of violet light appears to agree with the law of photochemical equivalence. Solutions of nitrogen trichloride in similar circumstances give less certain results not far removed from the requirements of the law. The mechanism of the photochemical decomposition is also discussed. A. E. G.

2010. *The Photochemistry of Potassium Permanganate. Part I. Application of the Potentiometer to the Study of Photochemical Change.* **E. K. Rideal** and **R. G. W. Norrish.** (Roy. Soc., Proc. 103. pp. 342–366, May 3, 1923.)—In investigating the effect of the light from the quartz mercury-vapour lamp on the electrode potentials of solutions of various electrolytes, a very marked and rapid change was noticed in the case of potassium permanganate; which recovers slowly to its original value when the light is extinguished. The nature of the effect suggested that it is the result of a photo-decomposition of the potassium permanganate and the research now described is an attempt to confirm the hypothesis and to discover the mechanism of the chemical change. The literature on the subject, which is very meagre, is renewed. The change in the electrode potential is shown to be due to an alteration in the P_H of the solution, brought about by a photochemical decomposition of the potassium permanganate. This decomposition makes itself apparent by the separation of a brown precipitate of the formula $K_2O . 2MnO_2$, and the formation of a red sol of manganese dioxide and potassium manganite in the solution. The electrode potential changes can be explained as a result of a production of KOH in the solution by the photo-decomposition of the $KMnO_4$, and a removal of the same by combination with the hydrated manganese dioxide; as a result, a photochemical stationary state ensues. The decomposition was mono-molecular over the range of concentrations investigated, and it was found possible to calculate the velocity constant by two independent methods from the electrode potential curves. These values were in good agreement among themselves, and with the constant determined by direct analysis of the decomposing solution. The addition of H_2SO_4 to the permanganate solutions was found to hasten decomposition, and to impose a zero molecular law of decomposition on the solution. This change in the type of decomposition was shown to be connected with the non-formation of colloid in the acid solution. Various substances were examined for photo-activity by the potentiometer method, among which ammonium nitrate, uranyl nitrate, and potassium hypochlorite gave definite positive results. A photolytic cell of potassium permanganate was constructed. H. H. Ho.

2011. *The Photochemistry of Potassium Permanganate. Part II. On the Energetics of the Photo-Decomposition of Potassium Permanganate.* **E. K. Rideal** and **R. G. W. Norrish.** (Roy. Soc., Proc. 103. pp. 366–382, June 1, 1923.)—It has been demonstrated in a previous communication [see preceding Abstract] that $KMnO_4$ is decomposed on illumination by light from the quartz mercury-vapour lamp. It is, therefore, of interest to determine the wave-length of the chemically active light and to investigate if possible the validity of the Einstein law of the photochemical equivalent, which so far has been stated not to apply to substances in solution. Accordingly the absorption spectrum of $KMnO_4$ was investigated, and a branch located between the limits 380 and 270 $\mu\mu$, with its head at 313 $\mu\mu$, while beyond 260 $\mu\mu$, a second band commenced. It was demonstrated that the visible radiations of the mercury-vapour spectrum were not appreciably effective in the decomposition of $KMnO_4$. Reasons are given by considering the line at 3128 Å.U., as the chief agent in the photo-decomposition by mercury-vapour light. The absorption of radiant energy by $KMnO_4$ was measured quantitatively, and with certain assumptions as to the active wave-lengths it is shown that 2 quanta are probably concerned in the photo-decomposition of the permanganate ion. The photo-sensitivities of mixtures of $KMnO_4$ and oxalic acid were examined by the potentiometer method, such mixtures being found much more sensitive to ultra-violet than to visible light. The mechanics of the photo-decomposition of the permanganate ion are discussed in the light of the experimental data obtained. H. H. Ho.

2012. *A Critical Search for a Heavier Constituent of the Atmosphere by means of the Mass-Spectrograph.* **F. W. Aston.** (Roy. Soc., Proc. 103. pp. 462–469, June 1, 1923.)—Ramsay showed in 1903 that xenon is only present in the air to the extent of 1 part in $1 \cdot 7 \times 10^8$ by volume, and Moore, dealing with the liquid residues from 100 tons of liquid air, concluded that no heavier constituent than xenon was present to the extent of 1 part in $2 \cdot 5 \times 10^9$ by volume. The element sought for must be an inert gas; and the two atomic numbers following xenon (54) in this group are 86 and 118. The practical possibility of a non-radio-active atom so massive as the latter may be dismissed, while one with the former atomic number would be an isotope of the radio-active emanations, now known as radon, thoron, and actinon; its atomic weight would probably lie between 210 and 230, and its boiling-point would be $-65°$ C. The material used in the investigation was collected in 1909 by the late Sir James Dewar from six months' working of Brin's Oxygen Co.'s plant; about 4 litres of liquid was finally obtained, the total volume of air from which this was extracted being about 439 tons; this liquid was poured on 1½ kilos of cooled cocoanut charcoal, in a 5-litre vacuum flask. Almost the whole of this was handed over to the author by Sir James Dewar, and the gas from it was carefully treated so as to remove oxygen, carbon dioxide, water-vapour, other carbon compounds, nitrogen and light inert gases; no less than 500 c.c. of practically pure xenon was obtained; and krypton could only be detected spectroscopically in it by careful fractionation. The whole of this xenon was fractionated steadily down to 0·02 c.c.; this residue was mixed with an equal volume of oxygen and examined in the mass-spectrograph; no indication of a line in the suspected region was obtained. Even if the gas sought for consisted of several isotopes the exposures used would have rendered detection certain at a concentration of the discharge gases of 1 in 1000; or 4×10^{-5} c.c. in the 0·04 c.c. of mixture used. If only one isotope were present 1 in 10,000 would be a more probable figure; the conclusion is that such a gas is certainly not present in the atmosphere in the proportion 1 part in 10^{15}, and probably not in the proportion 1 in 2×10^{16}. A faint band in the region corresponding to mass 150 is ascribed to Hg^{++++}; while an extremely faint and indefinite effect in the region 260 has not been explained. Sir J. J. Thomson has ascribed the faint parabolas he has observed at these points to diatomic molecules of krypton and xenon; but the author's observations are not in accordance with this view.

H. N. A.

2013. *Gaseous Combustion at High Temperatures. Part III. Energy-Absobing Function and Activation of Nitrogen in the Combustion of Carbon Monoxide.* **W. A. Bone, D. M. Newitt,** and **D. T. A. Townend.** (Roy. Soc., Proc. 103. pp. 205–232, May 3, 1923.)—The continued experiments [Abstract 943 (1922)] were made in a spherical bomb, of 242 $cm.^3$ capacity in four series: (1) With isothermic mixtures of $2CO + O_2 + mO_2 + nN_2$ (where $m + n = 4$); (2) same mixture, but mCO instead of mO_2; (3) same, mA (argon) instead of mO_2; the argon from the British Oxygen Co. contained 10% of nitrogen, but no other impurities; in these three series the initial pressure was $P_i = 50$ atmos. (4) $2CO + O_2 + nR$ (where $n = 2, 4, 6$, and $R = A, CO, O_2, N_2$); these experiments were started at various P_i (21 to 64 atmos.) with the $(2CO + O_2)$ mixtures to which the diluents R were then added in successive molecular proportions. It is found that nitrogen acts not merely as a diluent, but exerts a peculiar energy-absorbing influence far beyond that of the other diatomic gases and of argon; it retards the attainment of the maximum pressure P_m, diminishes the P_m/P_i ratio and hence the maximum temperature reached, and retards the cooling down. There is no correspondingly large (if any) energy-absorbing effect when nitrogen is present in the combustion of $(2H + O_2)$; the effect must therefore be due to a peculiar radiation emitted as the result of the interactions of CO and O; W. H. Julius suggested in 1890 such a radiation of 2·8 μ by the CO-flame, whilst the radiation emitted by the pure hydrogen flame had the wavelength 4·4 μ. In other words, N_2 and CO molecules, which have the same density, seem to have a constitutional correspondence such that the radiation emitted by the one is readily absorbed by the other. The presence of hydrogen (2 or 3 per cent.) suppresses this peculiar effect. In the absence of nitrogen CO will burn in O at high pressures almost as rapidly as hydrogen does. The effect of nitrogen may be due to an activation in the sense of Strutt, according to whom the after-glow of nitrogen is caused by the recombination of dissociated N-atoms; or it may be explained on Langmuir's lines, according to whom the molecules of both N_2 and CO can exist in two forms, an inert form in which the two positive nuclei are both situated within one and the same outermost shell of 8 electrons, and an active form in which they are situated within two separate shells having 4 electrons in common. Thirdly, ordinary nitrogen molecules might be set vibrating by the particular radiation emitted during the burning of CO, as stated. The results have a bearing upon the so-called suppression of heat in internal combustion engines and on the fixation of nitrogen; some nitrogen oxides were always found in the exploded gases. As regards the method of ignition, a thin platinum wire was used in the experiments, and the current from 12 accumulators, heating the wire to redness, was found more suitable than the current from the 110-volt d.c. main, which fused the wire. H. B.

2014. *The Electric Charges on Submicroscopic Particles.* **T. Sexl.** (Zeits. f. Physik, 16. 1. pp. 34–41, 1923.)—This paper is in part a comment on the work of L. Schiller [see Abstract 1633 (1923)]. Bär [see Abstract 2005 (1922)] is of the opinion that ultramicroscopic particles possess an appreciably smaller density than the original compact material from which they have been derived, and that through this smaller density the occurrence of subelectrons during charge measurements may be conditioned. Ehrenhaft on the other hand has emphasised the extreme improbability of the occurrence of Pt-particles of density 0·2, and dismisses Bär's assumptions as to the condition of the particles on the ground of the resistance law, also that Bär has 3 equations with 4 unknowns for the density determination of submicroscopic particles. Schiller has attempted to answer Ehrenhaft's objections by the assumption of non-spherical particles. The present author now attempts to show that neither the Schiller view, nor that of Bär, nor the Kaufmann-Regener assumption of an adsorbed gas layer at the surface of the particles, affords a critical explanation, and that a purely experimental determination of a resistance law for the motion of small spheres in gases, independent of any assumption as to the constitution of the electricity, must be obtained to solve the problem. H. H. Ho.

2015. *Sources of Error in the Measurement of the Electrical Charge of Colloidal Particles by the Method of Moving Boundaries: An improved Method based on a direct Measurement of the Potential Gradient across the Boundary.* **J. N. Mukherjee.** (Roy. Soc., Proc. 103. pp. 102–121, April 3, 1923.)—The only suitable method for measuring the electrical charge of fine colloidal particles which execute a rapid Brownian movement is the usual procedure of determining the rate at which a colloid-liquid boundary moves under unit potential gradient. The potential gradient is determined ordinarily by dividing the voltage between the two electrodes placed in the limbs of the tube by the effective distance between them. When applied to measurements with colloidal arsenious sulphide, it is found that the method gives wholly unreliable results. The unreliability of the method is found to be due to a variation in the resistance of the liquid at different places in the tube and to arise from (1) electrolysis at the electrodes and diffusion of the products, and (2) migration of ions across the boundary. An apparatus is devised to enable a direct measurement to be made of the potential fall across the boundary. Narrow tubes of 4-mm. bore are fused to one limb of the U-tube containing the liquid at four different positions at distances of about 1 mm. The colloid boundary is arranged to occupy a position intermediate between tubes 2 and 3. By connecting with calomel electrodes three potential measurements can thus be made and the changes in resistance which take place during the movement of the boundary followed. By using above the colloid a solution of hydrochloric acid of slightly higher conductivity than that of the colloid the boundary in the anode limb remains sharp and the method enables results to be obtained which are correct to within 5 %. The velocity of migration of particles of colloidal arsenious sulphide is found not to change appreciably with dilution. During a period of 21 days the velocity was found to be almost constant though a considerable amount of hydrogen sulphide had been formed by the decomposition of the sulphide. J. N. P.

2016. *The Indicator Method for the Determining of Coefficients of Diffusion in Gels, with Special Reference to the Diffusion of Chlorides.* **W. Stiles.** (Roy. Soc., Proc. 103. pp. 260–275, May 3, 1923.)—The method employed is to incorporate with the gel, before this has set, an indicator which reacts so as to give a precipitate or a coloured body with the substance of which the rate of diffusion is being measured. The diffusion is allowed to proceed upwards from a comparatively large quantity of solution into narrow glass tubes filled with the indicator-containing gel. The rate of progress of the precipitate gives a measure of the diffusion of the saturation concentration of the substances forming the precipitate. This rate of penetration (x) is found to follow a relation of the type: $x = k\sqrt{Dt}$, where D is the coefficient of diffusion, t the time, and k depends on the saturation concentration of the precipitated substance, on the concentration of the indicator in the gel, and on the composition of the gel. Absolute values of the coefficient of diffusion which avoid the use of k can be made from formulæ derived by Adair in terms of the rate of penetration of the precipitate, the initial concentration of the diffusing salt, the concentration of indicator in the gel, the coefficient of diffusion of the diffusing salt and that of the indicator in the gel. In measuring the coefficients of diffusion of chlorides, silver chromate is used as indicator by double decomposition of silver nitrate and potassium chromate. An observation is then made of the change from red chromate to white chloride, and, as the indicator is insoluble, its coefficient may be taken as nil and the calculation simplified.

The values obtained with a number of chlorides in 0·5 % agar gels are recorded. The coefficient of diffusion decreases with increasing concentration of gel. Empirical expressions are given to record this relation. The coefficient is found to increase with temperature and at a greater rate per degree rise in temperature the higher the temperature. The coefficient increases with decreasing concentration of the diffusing salt. An empirical expression is given to express this relation in the case of sodium chloride. J. N. P.

2017. *New Method of Measuring Corrosion in Water.* **F. N. Speller** and **V. V. Kendall.** (Indust. and Eng. Chem. 15. pp. 134–139, Feb., 1923.)—Confirmation is obtained of the conclusion that the amount of corrosion of iron is directly proportional to the concentration of the oxygen dissolved in the water. On this basis a new method for measuring corrosion is developed. This consists in cooling the water under pressure after it has acted on the metal and measuring, by the Winkler method, the fall which has occurred in the concentration of the dissolved oxygen.

The results are given of a number of series of experiments on the effect of velocity of flow on the corrosion of pipes. For velocities ranging from 0·0043 to 0·10 ft. per sec., corrosion increases appreciably with the velocity. With velocities lying between 0·10 and 0·80 ft. per sec., the corrosion increases rapidly as the velocity traverses the critical region marking its change from a viscous to a turbulent character, and then more slowly until a maximum is reached. Comparative curves are given for corrosion in ¼, ½, and ¾ inch steel piping at temperatures ranging from 60° to 170° F., the practical uses of the curves being indicated. The rate of corrosion in closed water systems under pressure increases directly with rise of temperature. T. H. P.

2018. *Mechanism of the Corrosion of Iron and Steel in Natural Waters; Calculation of Specific Rates of Corrosion.* **R. E. Wilson.** (Indust. and Eng. Chem. 15. pp. 127–133, Feb., 1923.)—The results of experiments conducted under varied conditions show that the rate of corrosion of iron and steel is influenced by over a dozen variable factors. The whole field of under-water corrosion may, however, be divided into three distinct ranges, in each of which the variables determining the corrosion are few and in general different from those predominant in the other ranges. The fundamental reactions involved are: (1) $Fe + H^{+} \longrightarrow Fe^{++} + 2H$, (2) $2H + \frac{1}{2}O_2 \longrightarrow H_2O$, and (3) $2H \longrightarrow H_2$ (gas). In alkaline solutions having values for p_H above about 11 or 11·5, reaction (1) is the slowest of the series and hence determines the rate of corrosion in this range; as a result, the corrosion is always comparatively slow, and the hydrogen-ion concentration and the temperature are the two most important variables.

In solutions with p_H lying between about 11 and 4, which is the case with almost all natural waters, reaction (2) is slower than reaction (1) but faster than the parallel reaction (3), so that it determines the rate of corrosion. Further, the slowest factor in this reaction is the rate of diffusion of dissolved oxygen through the stationary film of water on the iron surface, so that concentration of oxygen and velocity of flow are the two most important variables; temperature also is important, but less so than in the other ranges, while the effects of hydrogen-ion concentration and nature of the metal are negligible. In acid solutions having P_H about 4, reaction (3) becomes more rapid than reaction (2) and determines the rate of corrosion; in this case, hydrogen overvoltage, the nature of impurities in the metal, the temperature, and the hydrogen-ion concentration are the most important variables.

Certain popular misconceptions regarding the nature of "galvanic action" and the cause of pitting are discussed and the fundamental mechanism of these phenomena indicated. "Ferroxyl indicator" tests are shown to be unreliable owing to the depolarising action of the ferricyanide, and the danger of using accelerated corrosion tests as a basis for practical conclusions is emphasised. For corrosion in natural waters it is suggested that the specific rate of corrosion be defined as the loss in weight in milligrams per sq. cm. per year per c.c. of oxygen per litre. Conversion factors are given for conversion into other units. T. H. P.

2019. *Electro-Viscous Effect in Rubbersol.* **H. R. Kruyt** and **W. A. N. Eggink.** (K. Akad. Amsterdam, Proc. 26. 1 and 2. pp. 43–48, 1923.

In English.)—It has been stated that the viscosity of a solution of rubber in benzene is increased (decreased) by shaking it with a few drops of a solution of alkali (acid or salt). This effect is now confirmed for various acids and for mercuric chloride, which also reduces the viscosity of the solutions. On gradual addition of ammonia, the viscosity at first rises to a maximum and then descends. The relatively great change produced in the viscosity by a small proportion of an acid indicates the effect to be electro-viscous in character, but, whereas with the electro-viscous phenomena in water the curves for kations of equal valency coincide, this is not the case with the benzene rubber solutions; with the latter the real hydrogen-ion concentration appears to play a part.

With reference to the comparison of the qualities of different samples of rubber by measuring the viscosity of benzene solutions of the same concentrations, part of the viscosity is not related to the solvation but is of electrical origin and hence has a perfectly casual character dependent on the soluble components accompanying the rubber and having no influence on the mechanical properties in such minimum concentrations. Before making such comparison of viscosities, the electro-viscous effect must, therefore, be eliminated by judicious addition of the electrolyte. T. H. P.

2020. *Changes of Volume and Refractive Index Associated with* (*a*) *the Formation of Organosols and Gels, and* (*b*) *the Reversible Sol-to-Gel Transition.* **E. W. J. Mardles.** (Faraday Soc., Trans. 18. pp. 365–377; Disc., 378–385, Feb., 1923.)—Measurement of the volume changes associated with the formation of various organosols shows that, in general, such changes are largest at the lowest concentrations, with the best solvents and optimum solvent mixtures, and at the higher temperatures. The volume changes observed were much smaller in extent than those given by other authors. The deductions drawn from the density data are not so clearly indicated by the result of measurements of the refractive indices.

The reversible sol-to-gel transition is associated with a small volume change which varies with time as in the case of the Tyndall number changes, and there appears to be an intimate connection between the two phenomena. Indications are apparent also of a change of refractive index corresponding with the volume and Tyndall number changes during the reversible sol-to-gel transition. T. H. P.

2021. *Reversible Sol-to-Gel Transition in Non-Aqueous Systems. I. Change of Viscosity with Time during Gelation. II. Viscosity Changes Associated with the Gel-to-Sol Transition.* **E. W. J. Mardles.** (Faraday Soc., Trans. 18. pp. 327–364, Feb., 1923.)—The values obtained for the viscosity of a sol during its gelation depend largely on the method and conditions of measurement employed, and, since the system is heterogeneous, the values have no real significance. The change of apparent viscosity with time, determined under optimum conditions, during the gelation of a sol of cellulose acetate in benzyl alcohol, after about 15 minutes may be expressed by the empirical formula, $\eta - \eta_0 = ae^{kt}$, where η is the apparent viscosity of the gelating sol after an interval of time t, η_0 the original viscosity, a a constant depending on the concentration, and k the rate of gelation. The temperature at which the value of k becomes zero is regarded as the maximum gelation temperature, since at higher temperatures the sol is relatively stable and at lower ones a part of the whole of the dispersed particles aggregate to form a gel structure. The relation between the maximum gelation temperature and concentration resembles that between temperature and the saturation concentration for crystalloids.

During the transition of gel to sol in systems of cellulose acetate in benzyl alcohol, the viscosity diminishes, at first rapidly and subsequently more slowly until a constant value is attained. With many apparently fluid systems the final viscosity indicates the presence of portions of the original gel structure. The minimum solation temperature, which is the lowest temperature at which there is a complete return to the original viscosity of the sol without mechanical treatment, is given for various concentrations; mechanical treatment hastens solution and retards gelation. The time occupied by a system in obtaining constant viscosity or mobility depends largely on the age and previous treatment of the gel. The hysteresis effect observed during the sol $\rightleftarrows$ gel transition may be measured by the difference between the temperatures of minimum and maximum gelation and is attributed to the different conditions of the particles in the gel and sol state respectively. T. H. P.

2022. *Metal Sols in Non-Dissociating Liquids. Part I. Nickel in Toluene and Benzene.* **E. Hatschek** and **P. C. L. Thorne.** (Roy. Soc., Proc. 103. pp. 276–284, May 3, 1923.)—The investigation is devoted to the preparation of a metal sol in a liquid as free from ions as possible and to the study of the electrical behaviour of the sol. Stable sols are obtained by heating for 1¾ hr. at 100° C. solutions of nickel carbonyl in purified toluene containing a small amount of dried crêpe rubber dissolved in benzene to act as stabiliser. The sol produced is black and opaque in thicknesses over 2 cm.; and in thinner layers, or when diluted with organic solvents, it has a clear brown colour, and under the ultramicroscope shows vivid Brownian movements owing to the low viscosity of the medium. The sol resembles typical protected aqueous sols and is stable on dilution with other hydrocarbons, but is precipitated by liquids miscible with toluene which are not a solvent for rubber. No cataphoresis is observed with a p.d. of 10 v./cm. With 400 v./cm. between electrodes directly immersed in the sol a uniform brown film consisting of approximately equal weights of nickel and rubber is, after 1 hour's exposure, deposited on both electrodes. The weight of kathode deposit amounts to about 6 % more than that on the anode. A solution of rubber alone in toluene is found to give no deposit on either electrode. With different terminal voltages the amount of deposit from the nickel-rubber sol is found proportional to the linear ratio of the fields, whereas, if the charge on the particles were induced, the quantity transported should be proportional to the square of the field. The results indicate that the sol initially contains approximately equal numbers of positively and negatively charged particles. On applying an electric field to the sol the particles are seen under the ultra-microscope to drift in one direction or the other. When the polarity is interchanged, the motion frequently continues in the same direction and is not reversed. When the field is interrupted the particles suddenly cease drifting and resume normal Brownian movements. J. N. P.

2023. *Chemical Behaviour of Disperse Substances. Aluminium Oxide. Part II.* **V. Kohlschütter** and **Nelly Neuenschwander.** (Zeits.

Elektrochem. 29. pp. 246–256, June 1, 1923.)—Continuation of Kohlschütter's "topochemical researches" (Zeits. anorg. Chem. 105. pp. 1–25, 1919) which were undertaken to investigate how far the same solid condensation products, obtained by breaking down crystallised compounds of the same elements in various chemical ways, differ in their properties. In the previous experiments the reaction was locally restricted to the surface by letting ammonia (gas or liquid) act on crystals of aluminium sulphate or alum, and the formation of pseudomorphs of aluminium hydroxide (gels) was studied. The new molecules will form about centres in the old lattice, and the degree of dispersity of the product will depend upon the respective lattice structure and upon chemical and colloido-chemical processes. In the present paper aluminium hydroxide is prepared by precipitating grains of the same sizes of aluminium sulphate, basic acetate, or ammonium alum with ammonia of the same concentration, a stream of the grain flowing into the ammonia. The pseudomorphous grains of gels are dried; up to 40° C. they lose water without changing their volume appreciably, later the drying is much slower, but accompanied by pronounced shrinkage; dried at 120° finally, the powdery grains represented Al_2O_3 with 1·5 or 2 mol. of water. A discrimination between chemically and capillary bound water proved impossible. Physically the products differed much, owing to differences in the secondary structural elements and agglomeration. The chemical and colloidal properties, depending essentially upon the constituents of small dimensions, were easily reproducible. Concentrated hydrochloric acid dissolved all the products, actual solution being preceded by swelling; the diluted acid attacked the products chemically and gave sols; the sols contained all graduations from coarse colloidal particles to true molecular solution. Concentrated caustic potash and ammonia dissolved the particles, the diluted caustic did not yield sols; oxide from condensed alumina fumes behaved differently; it gave with caustic soda milky sols which were deflocculated by sulphuric acid; ammonia yielded under similar conditions, with acetate, alum and sulphate, clear, turbid, and milky sols. Sols formed by hydrochloric acid differ in their appearance and ultramicroscopically according to the mode of preparation of the dry gel. Diluted sulphuric acid did not form a colloid, though there was chemical attack. Electrolytic conductivity tests and ultra-filtration tests were also made. The behaviour of disperse aluminium hydroxide seems mainly to depend upon the reactivity corresponding to its chemical nature; but the disperse character asserts its influence, the colloido-chemical phenomena which precede complete solutions in concentrated acid being distinct, particularly in the case of diluted acid. There is no complex formation in definite proportions. H. B.

2024. *Variation of the Heat of Solution with the Temperature.* **P. Mondain-Monval.** (Comptes Rendus, 176. pp. 889–892, March 26, 1923.)—The results are given of measurements at 0° and at the ordinary atmospheric temperature, of the following magnitudes for sodium, potassium and ammonium nitrates, potassium and ammonium chlorides, and potassium sulphate: Q, the heat of solution in a large quantity of water; D, the heat absorbed by dilution of the saturated solution at the temperature of the experiment to the above dilution; e', the heat of addition of 1 mol. of water to a large quantity of saturated solution at $t°$; and e, an analogous quantity, but corresponding with a mass of water capable of dissolving at saturation 1 mol. of the salt at $t°$. L_1, the limiting heat of solution in saturated solution calculated by means of the expression, $L_1 = Q - D - e$, was checked by a slight extrapolation of the experimental results obtained by direct solution of the salt in more and more concentrated solutions; good agreement is thus obtained. In all cases the values at 0° differ appreciably from those at 16–19°. With potassium nitrate the amount of the heat change occurring on dilution of saturated solutions increases as the temperature rises, probably on account of the very rapid increase in the solubility. T. H. P.

2025. *Cryoscopic Study of Binary Organic Mixtures.* **N. Perrakis.** (Comptes Rendus, 176. pp. 1137–1140, April 23, 1923.)—Phenyl oxide, in marked contrast to phenol and *o*-cresol, gives with alcohol a freezing-point curve with a large section which is nearly horizontal. This curve is regarded as approaching the limit of non-miscibility. Similar sections are found in the curves for benzene with methyl, ethyl, isopropyl, and butyl alcohols; the range of this "flat" is greatest is methyl alcohol, showing that the miscibility of benzene increases as the molecular weight of the alcohol increases. Of the aromatic compounds studied, only cresol and phenyl oxide show good miscibility with alcohol in the sense of being far removed from the conditions in which immiscibility might arise.

T. M. L.

2026. *Purification of Liquids by the Simultaneous Action of Centrifugal Force and of an Electric Field.* **A. Marx** and **J. Rozières.** (Comptes Rendus, 176. pp. 1396–1398, May 14, 1923.)—The present investigation relates to the difficulties experienced in the industrial separation of colloidal substances from the fluids which hold them in suspension. The two modes of precipitation by centrifugal force and electrical action are first discussed and their attendant difficulties examined, the former requiring enormous power and the latter generally operating very slowly. The work of Hall on oleosols is referred to [see Abstract 2358 (1922)]. The authors now claim to offer a complete solution of the problem by the superposition of the above effects in an apparatus which they term an electro-centrifuge, and which in principle consists of a rotating bowl where the liquid is contained between two walls maintained at as different a potential as possible. Details are described for the case where in 5 mins. an obstinate colloidal suspension has been clarified, the potential gradient being 4000 volts per cm. H. H. Ho.

2027. *The Solubility Laws.* **A. Colson.** (Comptes Rendus, 176. pp. 1552–1555, May 28, 1923.)—With van't Hoff's conception of osmotic pressure Clapeyron's formula for saturated vapours becomes applicable to saturated solutions: $L = AT(U - u)dp/dT$. In that case L represents the heat of saturation, U the final volume of the solution saturated at T° by the expansion of the solid volume u of the dissolved molecule in the solvent V. When u can be neglected the modified formula $L = ART^2$ holds for diluted solutions. Le Chatelier has obtained a similar formula in which he substitutes concentration C for the osmotic pressure p. But, the author points out, this suggested equivalence of dC/dT and dp/dT deprives Clapeyron's formula of its rational character, and le Chatelier's formula is based upon the case of the slightly soluble iodine and is not applicable to NaCl, for which le Chatelier claims an inconceivable solubility minimum at T = 263°, nor to the many cases in which u is of the same order of magnitude as U and sometimes larger than V. The author proves this by various considerations and protests against the corrections which le Chatelier had applied to Colson's own data. In the case of highly soluble substances, where V is smaller than u, the solution has the character of a fusion rather than an expansion in the volume V. When V becomes zero, the condition of fusion is reached; the osmotic pressure p measures the force which expands the salt in a solvent of constant external pressure which is little affected by an addition at external pressure on the system. When V is really zero, there is no longer any solution, but a body of definite melting-point (eutectic). Thus the hexahydrate of $CaCl_2$ behaves above 30° like a definite liquid partly ionised and not like $CaCl_2$ fused in its water of crystallisation. The hydrate itself may be regarded as a special solvent showing for HCl and for certain chlorides a solubility which has no relation to the solubility characteristic of the partly free molecules of water. H. B.

2028. *Degree of Dissociation of Liquid Intermetallic Compounds. Heat of Mixing of Liquid Copper and Antimony.* **F. Sauerwald.** (Zeits. Elektrochem. 29. pp. 85–87, Feb. 1, 1923.)—From the specific volume isotherms of liquid alloys containing a chemical compound, minimal values for the dissociation of the compound may be calculated, but the variation of these minimal values with the temperature gives no indication of the exothermic or endothermic character of the compound. These considerations are illustrated by a study of the heats of mixing of liquid copper and antimony. T. H. P.

2029. *Volume Changes Accompanying Solution, Chemical Combination, and Crystallisation in Amalgams.* **A. W. Gray.** (Inst. of Metals, J. 29. 1. pp. 139–182; Disc. and Corres., 182–189, 1923.)—The writer analyses the reaction expansion which accompanies the chemical combination or decomposition when metals unite to form alloys, and refers to an original metallurgical hypothesis put forward to account for the peculiar alternation of contractions and expansions that a dental amalgam undergoes during and after the process of hardening. The paper is concerned largely with dental amalgams of silver-tin (with and without a small amount of copper), and silver-mercury, but reference is made to the value of the results to the study of die-casting phenomena, cement changes, duralumin, and invar steels, etc. The typical curves of reaction expansions are discussed at length, as well as the factors which influence dimensional changes. The effect of tin in prolonging solution and combination in silver-mercury amalgams, and its influence in facilitating contraction is considered. The writer presents additional experimental data in support of the hypothesis, and illustrates results with graphs and photomicrographs. The effects of varying the trituration time, of particle size, packing pressure, and temperature during hardening are considered at some length, experimental results and graphs being given. A. W. J.

2030. *The Mechanism of Recrystallisation in Amorphous Metal.* **A. K. Huntington.** (Inst. of Metals, J. 27. 1. pp. 315–323, 1922.)—The theory of G. Beilby which was advanced to explain the production of amorphous metal when work was done on crystalline metal has been investigated further, and some new information obtained on the process of recrystallisation in amorphous metal. It was demonstrated by Beilby that when work is done on the surface of a piece of metal for microscopical examination, an exceedingly thin layer of amorphous metal is ultimately formed on the surface of the prepared specimen; such a layer shows no structure, however, when etched in the ordinary way. The author shows by means of experiments upon the preparation and the microscopical examination of copper (kathode and electrolytic) and tungsten, that when the amorphous layer is crystallised apart from the main body of the metal, etched and examined microscopically, the amorphous layer crystallises from the outside inwards, and therefore independently of the crystalline metal beneath. He also shows that if the amorphous layer can be etched at temperatures higher than atmospheric, some interesting information is obtained, which demonstrates microscopically the process of the reconstruction of crystals in amorphous metals by the action of heat, and the nature of these crystals. A description of the methods of annealing the amorphous layer, and etching it, both when cold and hot, is given, and a number of microphotographs illustrating the results is also included. A. W. J.

2031. *Essential Factors in Cold-Treatment and Recrystallisation, according to Experiments on Materials made from Powdered Metals.* **F. Sauerwald.** (Zeits. Elektrochem. 29. pp. 79–85, Feb. 1, 1923.)—Experiments with copper and iron show that, in bodies prepared by pressing pulverulent material without deforming its constituents, subsequent treatment in the cold is able to lower the temperature at which granulation commences to an extent depending on the degree of deformation. An attempt is made to explain the static and kinetic conditions of cold-treatment and recrystallisation. Of the various factors involved, the effect on the condition of vibration of the atoms is regarded as of predominant importance. It is suggested that the production of a less stable distribution of the magnitudes of the amplitudes on the separate atoms results in increase in the amplitude with a certain proportion of the atoms. T. H. P.

2032. *Distortion of an Aluminium Crystal during a Tensile Test.* **G. I. Taylor** and **C. F. Elam.** (Roy. Soc., Proc. 102. pp. 643–667, March 1, 1923.)—Cylindrical rods consisting of a single crystal of aluminium [see Abstract 1029 (1922)] were machined so as to give a square section test piece 1 cm. × 1 cm. × 20 cm. This was pulled in a testing machine to give extensions of approximately 5, 10, 15, 20, 30, 40, 60, and 78 %, and careful measurements of the test piece were made at each stage. The crystal was also submitted to X-ray analysis. Mathematical analysis showed that, up to 40 % elongation the distortion of the specimen is due to simple shear in one direction, on, probably the (111) plane. Between 40 % and 78 % extension, at which latter value fracture took place, it appears that slip takes place on the two octahedral planes (111) and ($1\bar{1}1$). The paper is somewhat mathematical and unuitable for fuller abstracting. J. L. H.

2033. *Recrystallisation of Cold-Worked Cadmium.* **M. Cook.** (Inst. of Metals, J. 29. 1. pp. 119–132; Disc. and Corres., 132–137, 1923.)—Samples of cadmium were reduced, both by rolling and compression, by amounts varying between 20 % and 90 %. These samples were then submitted to annealing for various times at various temperatures. Annealing for 30 mins. at 200° C. and 150° C. causes recrystallisation in all specimens, while 30 mins. at 50° C. has no effect. Annealing at 150° C. causes the more severely deformed material to recrystallise, but has no effect on the less worked metal.

Hardness.—Material which has been compressed is much softer than the untreated material, the amount of softening being proportional to the degree of compression. This softening increased for several hours after the load was removed, then, in the case of the more severely strained material, a slight recovery of hardness took place, followed after about 2 days by a further softening, which continued for several days.

In the *discussion,* **Hanson** and **Carpenter** criticised the author for having omitted to consider the effect of the allotropic transformation of cadmium (at 60° C.) on the properties studied in his paper. **Greenwood** wrote on similar lines, while the **Author** did not consider that the possible existence of an allotropic transformation affected his results. J. L. H.

2034. *On the Relation of Structure and Strength in Works Materials.* **H. Mark.** (Elek. u. Maschinenbau, 41. pp. 265–267, May 6, 1923.)—Modern physics strives to show that the properties of bodies, such as elasticity, specific heat, heat conductivity, etc., can be explained by the particular grouping of molecules (atoms) and how these are bound together. As X-rays are light waves of much shorter wave-length, it occurred to Laue that the atoms in a body—a crystal—might scatter the rays. Friedrich and Knipping obtained definite interference patterns depending upon the form of the crystal. The apparatus used by the author in his work consists of a powerful parallel beam of X-rays from a tube working at 45 to 60 kw. and which could take 20 to 25 milliamperes per one hour. An aluminium window facing the antikathode allows the rays to pass through a lead tube of narrow bore on to the specimen under investigation; a photographic plate records the "atomic" radiogram. There were two questions to consider: (1) How are the properties of a crystal core related to the molecular properties? (2) How are the technical constants of a material dependent upon the properties of the crystal arrangement? It is the second that preponderates. There is a greater difference between hard and soft copper than between copper and aluminium of the same kind of hardness. A change in the molecule (Fe, Al) is of less effect in the radiogram than a change in the crystal arrangement. The question of how the elastic property of a crystal lattice of the atoms depended upon their arrangement was studied by the author in the case of single crystals of zinc and tin made up in wire form. He found that the elasticity of the (single crystal) wire depends upon the orientation of the crystal lattice arrangement to the wire axis. If the orientation was favourable the wire could be stretched to 150 times its length. He illustrates the mechanism by which the crystal planes interlock and how the crystal plane acts under the influence of tension. J. L. L.

2035. *Effects of Cold Work on Metals and on the Space Lattice as Revealed by Röntgen-Ray Studies.* **J. Czochralski.** (Zeits. f. Metallkunde, 15. pp. 60–67, March, and pp. 126–132, May, 1923.)—The strengthening of metals by cold work has been explained on (1) the amorphous state hypothesis, (2) the translation hypothesis, (3) the dislocation (verlagerungs) hypothesis; (2) by regarding the space lattice as indestructible, (3) as destructible. In support of (3) the author urges (*a*) that the phenomena of flow, though initially characterised by the formation of slip planes, proceed without further formation of slip planes, and (*b*) that in cold work the individual crystals can first be distinguished by differences in brightness (reflection), but that these differences disappear subsequently on further stressing when etching patterns are no longer discernible, though the grains remain distinct. Photographs reproduced of aluminium specimens, first compressed and then rolled down, make this clear. Further support is given by the systematic Röntgen-ray studies of the author made by the Laue method with single and complex aluminium crystals. When the pencil of rays passes through a single crystal, the radiogram is simple; when through two or more crystals in juxtaposition the pattern becomes indistinct; the same effect is observed when the thin specimen foils, each of a single crystal, are so placed above one another that the pencil passes through them successively. When the specimen contains many thousands of very small crystals the pattern resembles that of an isotropic material (amber). In a second series of experiments he starts again with a single crystal and forces the Brinell ball in at increasing pressures; the dots of the pattern become lenticular, they are displaced and finally radial lines are alone distinguishable (asterism). In a bent crystal of gypsum, which is neither turbid nor cleft with fissures, the ray patterns appear curved. Again, in single crystals of aluminium the asterism develops when the specimen is stretched on a traction machine and is further extended, after fracture, by cold rolling. The rays do not appear in all the quadrants and are not of uniform intensity; the asymmetry is connected with the orientation of the crystal with respect to the direction of the stress; the asymmetry vanishes when crystal conglomerates are stressed. When the specimen which showed asterism is recrystallised, the rays are resolved into patchy patterns again. The conclusion drawn is that, with advancing deformation of the specimen, striations appear on the dots of the Laue radiograms [which are markedly distinct]; the dots are radially and tangentially displaced, and rays are developed, some of which increase in intensity and change their direction, being rotated about the centre. The configuration changes when the direction of the stress is altered. These observations indicate progressive changes in the lattice structure, neither a mere slipping of the elementary units over one another, nor a disintegration of the units, but real dislocations in the lattice. Polarly-arranged atoms may possibly place themselves across the direction of the shear. H. B.

2036. *The Structure of Eutectics.* **F. L. Brady.** (Inst. of Metals, J. 28. 2. pp. 369–413; Disc., 414–419, 1922.)—The object of the research, the results of which are discussed in this paper, was to investigate the conditions under which the two phases of an eutectic separate, especially in the case of binary eutectics between metals and metallic compounds and to examine the causes of the observed phenomena.

The application and uses of eutectic alloys, to solders, silver coinage, fusible metals, and in general tin-base and lead-base bearing metals, is considered in an introductory section, followed by a brief bibliographical summary of the study of eutectics. Vogel's work on the quenching of eutectics of zinc-cadmium is discussed at length, and an account is given of similar experiments the results of which do not confirm Vogel's conclusions regarding the nature of the structure. The hardness of certain eutectics, in the slowly cooled and quenched states is studied, and the results illustrated with photomicrographs. The questions of the unity of the eutectic grain, the structure of the eutectic grain boundary, and the eutectic range are dealt with, and definite conclusions arrived at. In the third, and last section, a classification of the eutectics is suggested, namely, the four classes into which the eutectics examined fall: (1) Globular, (2) lamellar, (3) angular, and (4) crystalline. The powerful effect of surface tension in modifying the form of primary metallic crystals and the viscosity effect is referred to, a table of surface tensions for the more important metals being given. The paper is well illustrated with photomicrographs, graphs, and equilibrium diagrams, and useful tabular data are included giving the results of experiments relating to the physical properties of a number of binary eutectics. The subject of the eutectics in igneous rocks, with special reference to granites, diorites, and syenites is also considered. An appendix gives experimental details of the electric furnace used for melting the alloys referred to, the preparation of the specimens for microscopic examination, including the polishing, grinding, etching, and solutions used. A useful bibliography on the literature of eutectics is included, and the discussion on this paper contains certain interesting features. A. W. J.

2037. *Quenching Properties of Dead Mild Steel.* **M. Sauvageot** and **H. Delmas.** (Comptes Rendus, 176. pp. 1146–1148, April 23, 1923.)—A steel containing 0·09 % C. was quenched in water at temperatures varying between 950° C. and the melting-point; and the mechanical properties measured. It was found that quenching below 1350–1400° C. had little effect on the properties, while above this temperature the elastic limit, max. strength and hardness were greatly raised, and the elongation, reduction of area, and shock strength greatly reduced. The values obtained for maximum strength and hardness were:

Normalised, 37·5 kg./mm^2. and 114.
Quenched at 950° C., 52·5 and 170.
" " 1465° C., 86·5 and 286.

Steels quenched at and below 1350° C. appear to consist of ferrite and sorbite, while those quenched at and above 1400° C. consist of martensite and troostite or, at higher temperatures, of martensite only. Some experiments on annealing material quenched at high temperatures is also described. J. L. H.

2038. *On the Possibility of Hardening Dead Mild Steel by Quenching from very High Temperatures.* **M. Sauvageot and H. Delmas.** (Comptes Rendus, 176. pp. 1310–1313, May 7, 1923.)—The authors discuss the suggestion that the hardness conferred on extra mild steel by quenching from very high temperatures [see preceding Abstract] is due to the allotropic transformation $\beta \rightleftarrows \delta$, but bring forward evidence to show that this is not so. They suggest that it is due to the fact that the critical quenching temperature rises as the carbon content falls. J. L. H.

2039. *The Structure of Eutectics.* **A. M. Portevin.** (Inst. of Metals, J. 29. 1. pp. 239–273; Disc. and Corres., 273–278, 1923.)—

The microscopical structure of a large number of binary eutectic alloys has been examined, and a methodical classification has been made from the data thus obtained, due consideration being given to the work of previous experimenters. After some general remarks concerning the properties of eutectics, and solidification processes, the author considers both the size of the particles, and the three typical structures indicated by the results of a general examination of a large number of eutectics. He suggests the classification: Type 1. *Regular crystals,* of one of the constituents disseminated in the other constituent forming the ground mass of the alloy. Type 2. *Dendrites* or *Skeleton crystals,* with certain sub-classifications. Type 3. Arrangement in *Eutectic colonies,* or as complex grains more or less spherulitic. Reference is made in an extended description of microphotographs of various eutectic alloys, to the work of Rosenhain and Tucker, and to Vogel's conclusions. The paper includes also an account of the power of spontaneous crystallisation of alloys, and of the modes of alternate, simultaneous, and successive crystallisation, with reference to graphs showing temperatures and concentrations. Factors, such as the linear speed of crystallisation, the influence of surfusion, and of the pro-eutectic constituent, of currents in the liquid, of the rate of cooling, and of surface tension are dealt with, each at some length. The paper concludes with a discussion of the relation between the structure and the properties of eutectics, more particularly in respect to the hardness. An appendix contains some interesting information concerning the results of experiments made, subsequently to the publishing of the paper, for the purpose of examining the process of deformation of eutectic conglomerates, previously polished specimens of the eutectics, tin-lead, lead-cadmium, cadmium-zinc, being examined microscopically after deformation. Another appendix deals with experimental results relating to the coalescence of eutectic particles, and the hardness and recrystallisation of eutectics, with some practical remarks on the possible applications of eutectic alloys. [See also Abstract 2036 (1923)]. A. W. J.

2040. *Grain Growth and Diffusion in Alloys.* **J. H. Andrew** and **R. Higgins.** (Inst. of Metals, J. 28. 2. pp. 185–194; Corres., 195, 1922.)—A composite bar of copper and brass is heat treated and examined to find the relative importance of grain growth and diffusion at various temperatures. At low temperature diffusion is predominant and promotes the breakdown of the grains while at higher temperature grain growth may predominate. The boundaries between adjacent crystals of similar material are considered to be zones of discontinuity in the ordered arrangement. If a crystal be stressed internally and then heated, the molecules may align themselves with those of neighbouring crystals rather than with each other and hence the individuality of the grains is changed. A. Wh.

2041. *Crystallographic Alterations in Lead-Bismuth-Tin Alloys.* **K. Bux.** (Zeits. f. Physik, 14. 5. pp. 316–327, 1923.)—Alloys were prepared containing various atomic proportions of the metals, such as $Pb_1Bi_4Sn_4$, $Pb_2Bi_4Sn_4$ (Rose's metal), $Pb_3Bi_4Sn_4$, etc., with others in which the proportions of Bi and Sn were varied. These were cast on plain surfaces of plate glass or mica, and when removed showed in most cases a mirror surface, which was for some of the alloys very perfect. As the metal cooled the surface altered, showing a change in the crystalline structure, the temperature at which the change took place varying with the constitution of the alloys, some of which (those not far removed from the eutectic composition) rose in temperature, or cooled more slowly, when crystallisation began. Interesting observations were made on the effect of heat treatment, such as quenching and subsequent reheating, and similar experiments were made with binary alloys such as $PbSn_3$, Pb_3Bi_4, Bi_2Sn_3. Bismuth appears to have two allotropic modifications, the change taking place at 75°. The experiments seem to indicate that the change temperature is lowered by the addition of tin and particularly of lead. Mixtures which are nearly eutectic cool down to the change-point without any essential change in their surface. If one component is largely in excess crystals (presumably of this component) separate out before the change-point is reached. Quenching the alloys causes super cooling, and the process of change is greatly retarded or prevented. H. N. A.

2042. *Adsorption from the Gas Phase at a Liquid-Gas Interface.* **T. Iredale.** (Phil. Mag. 45. pp. 1088–1100, May, 1923.)—Measurements are made of the surface-energy changes of a liquid under various pressures of an adsorbed vapour at the liquid-gas interface, the adsorbed vapour being present, not in solution in the liquid phase, but as a constituent of the gas phase only. The amount of the adsorption can then be calculated from the Gibbs equation $\Gamma = -\rho d\sigma/dp$, where Γ is the surface excess of adsorbed vapour, ρ the density of the vapour, and $d\sigma/dp$ the rate of change of the surface tension of the mercury with the partial pressure of the vapour. The first part of the paper is concerned with the development of a suitable method of measuring the surface tension of a liquid under the condition of a continuously varying vapour phase. A table is given from results by Harkins and Brown giving the ratio r/r^1 of the radius of tube (r) and the radius of the drop (r^1) with a continually varying radius of tube, for water. With the aid of this table, and the equation of symmetry, $K^2 = T_1\rho_2/T_2\rho_1$, K being the ratio between two similar linear dimensions of the drops, the surface tension of any liquid of known density may be found. This "drop-symmetry" method is then employed to determine the adsorption of some organic vapours by mercury. A curve connecting the "Surface tension of mercury" with the "Partial pressure of methyl acetate" shows that the surface tension decreases from about 470 dynes per cm. to 420, while the partial pressure of the vapour rises from 0 to 60 or 70 mm., and remains nearly constant until the partial pressure reaches about 230, when it may have any value from 412 to 370. A calculation from the formula $\Gamma = -\rho d\sigma/dp$ of the adsorption for a vapour pressure of 62 mm. leads to a value for the number of methyl-acetate molecules per sq. cm. of mercury surface of $0{\cdot}37 \times 10^{-15}$. This value is very near the values given by Langmuir for monomolecular layers of CO_2, N, etc. The space taken up by each molecule (27×10^{-16}) is near that required for molecules of esters and fatty acids on the surface of water, *viz.* 23×10^{-16} sq. cm., and it seems likely that the same type of orientation occurs on the mercury surface as on water. T. B.

2043. *Chemical Constants of Diatomic Molecules.* **R. R. S. Cox.** (Cambridge Phil. Soc., Proc. 21. pp. 541–551, June 15, 1923.)—In the case of diatomic substances the molecular rotations must be taken into account, but in many instances the rotations reach their equi-partition values at such low temperatures that in any temperature region in which experimental measurements are available, they may be regarded as fully excited. The assumption, then, is that they have been fully excited from absolute zero upwards, and this leads to a different value of the chemical constant, the theoretical expression for which has been given by Ehrenfest and Trkal [Abstract 1576 (1921)] and Fowler [Abstract 1484 (1923)], *viz.* Γ (diatomic) $= \log\left\{(2\pi m)^{3/2} 8\pi^2 J k^{7/2}/\sigma h^5\right\}$, where J is the moment of inertia of the molecule, and σ its "symmetry number," *i.e.* the number of orientations in space in which it is statistically equivalent. The constancy depends on that of $\log T - \log B(T)$, where B(T) is the partition function for the rotations as defined by Darwin and Fowler [Abstract 65 (1923)]. The present paper is an attempt to calculate the values of Γ (diatomic) for those diatomic gases for which suitable data are available, with the object of testing the above theoretical formula. The substances discussed are the halogens: I, Br, Cl; and N. Except in the case of N, in which there is very good agreement, the values of Γ obtained from dissociation, vapour pressure, and theory are in considerable discordance with each other; those from the vapour pressure being systematically much higher than those from the dissociation. In particular, it was impossible to draw any conclusion with regard to the validity of introducing the symmetry number σ into the formula for the chemical constant except again in the case of N, where omission of σ would quite destroy the agreement. It seems quite possible that this discordance may be a genuine one having a theoretical basis; but this cannot be asserted definitely until further experimental data are available. Accurate and numerous measurements of p and Kp; further information as to the specific heats of the vapour and of the solid or low temperatures, and measurements of the band spectra are necessary before much further progress can be made. G. W. DE T.

2044. *The Potential Difference occurring in a Donnan Equilibrium and the Theory of Colloidal Behaviour.* **A. V. Hill.** (Roy. Soc., Proc. 102, pp. 705–710, March 1, 1923.)—It is contended by Loeb that the Donnan membrane equilibrium, involving the presence of an indiffusible ion, is the basis of the colloidal properties of a protein solution. While the possibility of this conclusion is admitted, it is pointed out that one of the chief arguments employed in its favour by Loeb is incorrect. Loeb shows that the p.d. observed experimentally between a protein and a non-protein solution separated by a membrane agrees very closely with that "calculated" from the difference in hydrogen-ion concentration also observed experimentally, and concludes that this supports the theory.

It is pointed out in the present paper that the equality found by Loeb of the observed p.d. to that calculated from the difference of pH, is a necessary consequence of any mechanism in accordance with the second law of thermodynamics. This argument proves no more than that the system investigated was in equilibrium and, in itself, offers no support to the theory that the Donnan equilibrium underlies the colloidal behaviour of protein solutions. J. N. P.